THE EFFECTS OF GENDER, KNOWLEDGE AND LEARNING OPPORTUNITIES ON SCIENTIFIC CREATIVITY AMONGST FORM THREE BIOLOGY STUDENTS IN NAKURU DISTRICT

BY

GRACE CATHERINE WANJA NDEKE

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DECLARATION

I declare that this thesis is my original work and has not been presented before for an award of a Degree or Diploma in any university.

....

Grace C. Wanja Ndeke.

29/4/2003
Date

APPROVAL

This Thesis has been submitted for examination with our approval as university supervisors.

1. Prof. M. Okere — Sign: .... Date: 29/4/03

2. Prof. Ong'ondo — for Sign: .... Date: 29/4/2003

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DEDICATION

This thesis is dedicated with love to my husband Daniel Ndeke and my children Denning, Lynn and Denys.

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ABSTRACT

Biology Education aims at enabling the learner to develop and use scientific creativity skill as well as acquire biological knowledge, to participate in the development of Kenya's economy. Adequate preparation of biology students in the subject in secondary schools is therefore essential. In addition, the level of scientific creativity among biology students and factors influencing its development need to be understood. However, few studies have been done in Kenya with regard to this skill. Therefore, the purpose of this study was to investigate the level of scientific creativity and the effects of gender, knowledge and learning opportunities on scientific creativity amongst form three biology students in Nakuru district. The research methods for the study were a cross- section survey and a case study. The population of the study consisted of all form three biology students in public secondary schools in Nakuru district. A sample of eight schools with a total of 363 students was selected from the population using stratified random sampling technique. Three schools from the sample were used for the case study design. The researcher administered biology achievement test and biology scientific creativity test instruments to the students and also conducted classroom observations of biology lessons in the sampled schools. The test items were pilot tested in two schools in the district for validation. The pilot schools were not involved in the main study. Data analysis was done using both qualitative and quantitative methods. Quantitative data was analysed using Pearson Product Moment Correlation Coefficient, chi-square, t-test and One-way ANOVA. Statistically significant findings were tested at 0.05level. Scientific creativity test and the classroom observations were analyzed qualitatively.

The findings of this study indicated that the general level of scientific creativity in biology was low. The findings also indicate that the learning opportunities provided during the biology lessons are inadequate for effective acquisition of scientific creativity skill. The findings also indicate that the level of scientific creativity was gender dependent in favour of boys and also dependent on school category. All aspects of scientific creativity were also found to have a relationship with gender and school category with the exception of planning. A significant difference in performance in the biology scientific creativity test by gender and school category was also identified. The findings further suggest that scientific creativity is also knowledge dependent. The implications are discussed.Recommendaions on how to improve scientific creativity skill in schools are given.

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CHAPTER ONE

INTRODUCTION

1.1 Background Information.

One of the main objectives of education in Kenya is the development of creative and innovative minds amongst learners (Republic of Kenya, 1999). This is because accelerated industrial development can only take place if future manpower is trained to think creatively. Kenya is a country that hopes to be industrialised by the year 2020 (Republic of Kenya, 1992 & 1997) and hence the need to develop the creative skill amongst our students.

Treffinger (2002, Ed.), argues that much of what we know today we did not know four decades ago, and in the not-very-distant future much of what we think we know now, will be absolutely irrelevant. So he asks, "what do students need to be prepared for the long journey of discovering for themselves how good they can be?" He answers the question by saying that they need information, including knowledge and expertise in some domain. But knowledge in itself "knowing about" something will be insufficient and transient. He further argues that the "shelf life" of knowledge in this time of constant change, how long knowledge lasts before it is overcome by events or replaced by new, better or different knowledge, is getting shorter and shorter. So, he explains that, they will need another kind of information and tools: "Knowing how" to access, organise, modify, use and construct information. They will also need discipline or what we call a strong work ethics, the skill and willingness to put long hours to do the hard work and to struggle with complex works.

Loehle (1990) mentions four requirements for a successful career in science: knowledge, technical skills, communication and originality or creativity. He further argues that those areas of science, as biology, anthropology, medicine and theoretical physics need more creativity because the phenomena are complex and multivariate.

The term creativity has been used and given different meanings in different fields. According to the heritage dictionary, originality and imagination characterise creativity. Some of the important instances of creativity include discoveries of knowledge in science and medicine, invention of new technology, composing beautiful music or analysing situations in a new way (Standler, 1998). Standler further gives an example of creativity as George de Mestral's observation of how cockleburs attach to clothing. This led him to invent the hook and loop fastener. In this, he transformed a common nuisance to a useful product. Crawford (1954) is credited with starting a training course to increase creativity among professionals by use of attribute listing. This involved putting down certain attributes of a product and the modifications that could be done to each attribute to improve the product.

Treffinger *et al* (2000) defined creativity with emphasis of the importance of balance between creative and critical thinking during effective problem solving and decision-making. They define creative thinking as involving the encountering of gaps, paradoxes, opportunities, challenges, or concerns, and then searching for meaningful new connections by generating many possibilities, varied possibilities, unusual or original possibilities, and details to expand or enrich possibilities. They go further to suggest that critical thinking involves examining possibilities carefully, fairly, and constructively, and then focusing thoughts and actions by organising and analysing possibilities, refining and developing promising possibilities, ranking or prioritising options, and choosing or deciding on certain options.

In psychology the major emphasis is on differences between individuals in the abilities, personality and characteristic that underlie the production of artistic or scientific work, which is generally recognised, as creative and original. What various kinds of talents can be distinguished and perhaps measured? What are their origins? What promotes and hinders their development? (Vernon, 1982). Treffinger *et al*, (2001,Ed.) discusses research efforts that have focused on identifying traits that distinguish creative people from those that are not. These include cognitive characteristics (the way people think), personality traits (ones values, temperament, and motivational disposition), and biographical events (the things that happen or experiences one has during ones lifetime.

Galton (1869) published his hereditary genius, which was the first attempt at an empirical study of human abilities, which viewed men of genius not as a kind of rare part, but as extreme top of continuous distribution. However according to Vernon (1982) Charles Spearman in London and Alfred Binet in Paris pioneered the basic principles of measuring mental abilities, in the first decade of the twentieth century. Galton defined creative ability as a composite of intelligence, motivation and power. Spearman emphasised the supreme importance of the general intelligence factor in all types of achievement, and both looked to heredity rather than environment as a source of greatness. This assumption implied that even genius thrives on opposition and difficulties. Nevertheless, current educationists' concern is whether current methods of teaching, testing and examining at school and university may not unduly favour the conformist mentality and discourage spontaneous, independent thought among those children or students who might make future original contributions to the arts, sciences and technologies.

Terman (1926) after his life-long studies deplored the lack of recognition and encouragement of brighter children in American schools. Both teachers and parents, it seemed wanted to produce the conventional, socially well-adjusted child and viewed the unusually talented student with suspicion. Terman's studies made a considerable impact on the American curriculum and during the 1930's and 40's there was emphasis on enrichment of the curriculum. But it was the advent of Sputnik in 1957 that shocked America into asking whether its educational system was failing to produce sufficient original scientists to maintain its technological lead in the modern world.

Another turning point was Guilford's (1950) paper that pointed out that almost all the tests and achievement examinations used by American psychologists and educationists were 'convergent' that is, for each item there was one predetermined correct answer. Clearly these put the imaginative or independent thinker at a disadvantage. Creative thought is more likely to issue in a variety of new answers, that is, to be a divergent thinker. Many investigations of creativity test followed together with a spat of publications on the need for early recognition of children with unusual ideas and talents.

A good deal of confusion in the area of creativity arises from loose usage of terms like creative, original, imaginative, non-conformist, gifted, talented, genius etc. Whereas some writers are talking about people like Mogart and da Vinci, or about highly productive and original artists or scientists of the present and the future, others are referring to children or adults who score well on divergent thinking test in a very different matter. Still others refer to the exceptionally able students from the top one or two percent in Intelligence Quotient (I.Q) and achievement or even to the top twenty percent in the well above average. Again there are many kinds as well as degrees of creativeness (Vernon, 1982)

An unanswered question posed by Vernon, (1982) is "Why so far women have not shown outstanding creativity in any field?" Is it that they are not creative or they are not provided with learning opportunities that enhance the acquisition of scientific creativity? This will be one of the focuses of the study. There are also signs that culture affects creativity but not much work has been done in this area. However this is not part of the study.

Environment may also affect creativity. For example Cattell (1906) compared the numbers of men of science born in different American States, which varied in wealth, educational advance and social traditions. He found that the numbers of men of science increased with the increase of wealth, educational advancement and social advancement in the states. Knapp (1963) has shown in his work that certain universities or institutions produce more creative research than others. This gives an indication that there are some social and educational factors that make the institutional climate that contributes to creativity. Okere (1986) showed in his research that both physics knowledge and context of application contribute to creativity. It is therefore interesting to find out whether the same position can be obtained in other science subjects like biology, especially the effect of knowledge in biology on scientific creativity.

Okere (1986) has given meanings of scientific creativity that can be taught and assessed in our Kenyan schools. These include sensitivity, flexibility, and recognition of relationships and planning for investigation. According to Burt (1962) education cannot create creativity but can encourage it and develop it. Treffinger *et al* (2001, Ed.)) and Loehle C. (1990), support this further by mentioning that many characteristics associated with creativity are not innate but can infact be taught and nurtured. They go further to argue that creative behaviour is influenced by motivational as well as situational factors. Parnes (1963) explains the role of educational experience in developing creative scientific talents. He goes further to argue that creative activity represents to some extent many learned skills and hence learning could extend the skill within limitations. Polya (1957) also supports this by stating that skillful teaching can enhance the ability to discover and the ability to invent.

Creativity is important in science since science is changing rapidly with many discoveries, hence spoon-feeding in schools cannot help learner's develop creative skills (Ennis, 1989). Treffinger (2001) points out the importance of creativity. These include

- Creative learning helps students to deal effectively, independently, and resourcefully with many complex opportunities and challenges.
- It helps students to deal effectively with future problems and challenges that neither they nor we can even anticipate at the present time.
- It can have a very powerful and positive impact on students' preparation for future careers.
- It offers rich and varied opportunities for personal growth, expression, and productivity.
- It leads to great satisfaction and reward.

The above points on the importance of creativity indicate that creativity is very important for future career preparation among learners. This shows that it is important to inculcate this skill among learners to prepare them for future careers and if Kenya is to be industrialised by the year 2020(Republic of Kenya, 1992).

Accountability tests tend to drive the curriculum (Lomax et. al., 1992; Resnick & Resnick, 1992). Traditionally the process of testing and evaluating science learning generally leans towards determining learners' acquisition of scientific content (Otieno, 1991). In the light of the importance of creative skills in the doing of science, it became imperative to find out how

Kenyan learners perform in the creative skill. Consequently, it was felt that an exploration of learners' competence in the creative skill would make a contribution towards understanding learners' potential in the field of science, an area clearly important for technological development of third world countries as noted earlier.

1.2 Statement of the Problem.

Biology syllabus emphasises creative ability in students, by stating that learners should demonstrate resourcefulness relevant technical skills and scientific thinking in familiar and unfamiliar situations. Also, learners should be able to design, carry out and evaluate experiments and projects (KNEC, 2000). These are aspects of scientific creativity. Creativity as a skill is important for scientists. However the effects of gender, knowledge and learning opportunities on scientific creativity have not been explored in Kenya, and yet they affect creativity. Therefore, the focus of this study was to investigate the effects of gender, knowledge and learning opportunities among form three biology students. Also there is no documented evidence that teachers are providing the opportunities necessary for inculcating this skill amongst the students.

Okere's model has been used in Physics to measure scientific creativity (Okere, 1986). This model has not been applied in other science areas like Biology. Therefore there was need to use the model to measure the level of scientific creativity in Biology.

1.3 Purpose of the Study.

The purpose of this study was to investigate the level of scientific creativity in biology amongst form three students, and explore the effects of gender, knowledge and learning opportunities on the level of scientific creativity.

1.4 Objectives.

From the statement of the problem and the purpose of the study the following objectives were formulated to guide the study:

1. To describe the level of scientific creativity amongst forms three biology students.
2. To determine if there is any relationship between the learners' level of scientific creativity and knowledge in biology.
3. To determine if the learners' level of scientific creativity in biology is gender dependent.
4. To determine if there is any difference in learners' performance in the biology scientific creativity test by gender.
5. To determine if there is any relationship between the learners' level of scientific creativity in biology and school category.
6. To determine if there is any difference in learners' performance in the biology scientific creativity test by school category.
7. To find out if biology teachers' provide learning opportunities that enhances the acquisition of scientific creativity.

1.5 Hypotheses.

The following null hypotheses were formulated for this study:

Ho_1: There is no significant relationship between the learners' level of scientific creativity and knowledge in biology amongst forms three biology students.

Ho_2: There is no significant relationship between the learners' level of scientific creativity and gender amongst form three biology students.

Ho_3: There is no significant difference in learners' performance in biology scientific creativity test by gender.

Ho_4 : There is no significant relationship between the learners' level of scientific creativity in biology and school category.

Ho_5: There is no significant difference in learners' performance in biology scientific creativity test by school category.

1.6 Significance of the Study.

This study was sought to provide empirical data on how certain factors related to the learner and the teacher affect scientific creativity in biology. The understanding of these factors will help the curriculum developers at the Kenya Institute of Education (KIE) and the Kenya National Examination Council (KNEC) because additional data will be available for developing biology curriculum and making evaluation decisions. Teacher trainers would also benefit from the study in helping them to modify their curriculum to include the aspect of creativity. Also biology teachers may use the results of this study to provide appropriate opportunities during biology instruction to encourage scientific creativity among the learners. Students after having been trained in creativity would benefit in the long term in that; they would deal effectively, independently and resourcefully with many complex opportunities and challenges. They would also deal effectively with future problems and challenges that neither they nor we can even anticipate at the present time and also prepare them for future careers.

1.7 Assumption of the Study.

This study was carried out with the following assumptions.

1. All form three biology students had effectively covered the form 1 and 2 biology syllabus.

1.8 Limitations of the Study.

The study would have included as many factors as possible in order to get a better view of the factors affecting scientific creativity among biology students. However this study was limited to only three factors, that is, gender, learning opportunities and knowledge in biology. The study was limited to only eight schools in Nakuru District therefore generalisation of the results was limited to this district.

1.9 Operational Definition of Terms.

The following are definitions of terms as used in this study.

Biology is the study of life and is taught as a subject in Kenyan secondary schools with systematically organised pre determined curriculum, which is implemented mainly through classroom instruction and laboratory practice within a specified period of time.

Biology achievement test is a measure of the student's understanding and mastery of the basic principles and concepts in biology.

Form Three is the third level in the secondary school phase in Kenyan Education system.

Gender refers to the socially determined personal and psychologically characteristics associated with being male or female namely 'masculinity' and 'femininity' (Garret, 1992), but according to this study gender is the students learned behaviours associated with ones' sex.

Knowledge refers to the score the learner acquired in the Biology achievement test.

Learning opportunities are the activities provided by the biology teachers to the learners to encourage scientific creativity. These include resources available and methodology used by the teachers.

Level of Scientific creativity is described as low or high depending on the criteria reference of 40%of the total scores obtained by the students on the scientific creativity test.

School category refers to the type of school depending on whether it is single sexed school (girls and boys schools), or mixed school (girls and boys learning together).

Scientific creativity is the possession of the following skills by the form three biology students: sensitivity, flexibility, recognition of relationship and planning for investigation, where by:

- **Flexibility** is the ability of the student to give a variety of ideas or solutions to problems.
- **Planning for investigation** is the ability of the student to devise experiments to test hypothesis.
- **Recognition of relationship** is the ability of student to generate hypotheses regarding the causes of given phenomena or observations.
- **Sensitivity** is the ability of the student to be able to site problems in any design of investigation and give possible solutions to the problems.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction.

This chapter reviews literature related to scientific creativity and examines the general, psychological and scientific meanings of creativity. It also reviews literature related to other variables included in the study, namely, the learning opportunity provided in schools to encourage scientific creativity and gender. The chapter finally derives the conceptual framework as a basis of the study.

2.1.1. Meanings of Creativity.

The concept of creativity has been used frequently in various fields of study with different meanings. According to Galton (1869) creativity is a natural mental ability that is inherited. He carried out biographical studies of eminent judges, statesmen, literary men, scientists, and artists'. He found that whereas fathers and grandfathers of others were themselves eminent those of scientists only few were eminent. This contradicted his hereditary theory of creative ability. However Cox (1926), conducted a biographical study of eminent scientists, soldiers and lawyers, and found that the genius that achieves the highest eminence is one whose intelligence test would have identified as gifted in childhood. She however warns that intelligence is a necessary but not sufficient condition for eminence.

Guilford (1952) remarked that "like most behaviour, creative ability probably represent to some extent many learned skills". Loehle's (1990) idea agrees with this by pointing out that creativity is not strictly an inherent trait, but one that can be developed and cultivated. Davis

(1974) mentions the diversity of creative acts as simply the abstract quality of fanciful resourcefulness itself.

According to Wallas (1926), Ausubel and Robinson (1974) achievement of creative thoughts results in making a new generalisation or invention or the poetical expression of a new idea. Wallas (1926) and Freeman *et al* (1971) explain that creative thought is brought about in four stages, that is:

- Preparation stage where the problem is investigated in all directions,
- Incubation stage where one is not consciously thinking of the problem.
- The third stage is the illumination when the 'happy' idea appears.
- Verification is the last stage.

In all these stages intellectual education is necessary since the acquired body of facts and words gives one a wide range and the moment of association.

Bartlet (1958) points out the characteristics of experimental thinking, which shows creativity. One characteristic is that a scientific experimenter is an opportunist who builds upon facts available to him and uses them to discover other facts. Experimental thinking also demands multiple interests especially when it comes to the method and instrumentation. There is also the concern of pinpointing or siting problems, adapting new methods and instruments for use in the new field and show that they can be used to reach a compelling answer to some current problems. Another characteristic is originality, which is the capacity to detect overlap and agreement between group of facts and fields of study, which have not been effectively combined before.

Imagination is another quality of creativeness in man (Sinnot, 1959). He further mentions that the process of creativity can be through deduction or can be spontaneous. Cropley (1967) argues that a creative thinker is above all flexible and adaptable in his/her intellectual functioning. He further mentions that in the cognitive domain, creative individuals are characterised by possession of wide categories, willingness to take risks, willingness to 'have a go' and high levels of flexibility.

According to McMahon and McMahon (1982) creativity is the ability to 'break set'. They further add that creativity is a potent factor in intelligent behaviour. Torrance (1959) defines creativity as 'the ability to be aware of problems, think of possible solutions to the problems and test the practicability of the solutions'. Heritage dictionary defines one who is creative as characterised by originality and expressiveness and imaginative. Macquarine dictionary defines one who is creative, as one who has been generative ground breaking, innovative and original. Concepts used synonymously with creativity are imagination, ingenuity, innovation, intuition, invention and discovery and originality (Freeman *et al*, 1971). In general creativity just accounts for the process of recognition or discovery of novel ideas and solutions. However, Davis (1974) looks at creative individuals as being characterised by their habitual preference of originality, their curiosity and flexibility and their willingness to differ and to take risks. Intuition has also been listed among the essential creative qualities for scientists (Garfield, 1990).

Treffinger *et al* (2000) looks at creativity as the ability to generate ideas. He defines it further as an open exploration or search for ideas in which one generates many ideas (fluency in thinking) varied ideas and new perspectives (flexibility) and unusual or novel ideas (originality). Then focus further on one's thinking by identifying ideas with interesting or exciting potential to refine, develop and put to use. Another associated trait of creative individual is that they are divergent thinkers (Guilford, 1959). They move away from responses already known and expected like in convergent thinking which moves towards responses that fit to the known and specified (Razik, 1967). Divergent thinking is taken to be the cognitive ability of generation of ideas (Treffinger, *et al,* 2002, Ed.). They further mention the characteristics associated with this as fluency, flexibility, originality, elaboration and metaphorical thinking which can be measured. However, Brophy (1998) argues that a complete creative problem solving process requires divergent ideation alternating with convergent evaluation and the ability to judge when one is appropriate. He also points out that divergent thinkers are more likely to process diverse stimuli, organise thoughts, flexibility, seek knowledge about varied subjects, and form intuitions, and they are more intrinsically motivated to solve problems creatively. The experimental test used to measure creativity emphasises divergent thinking, which subsumes, originality, fluency of ideas, flexibility, and sensitivity to defects and missing elements and the ability to elaborate and redefine. McRae (1987) and Runco and Okuda (1988) report that studies in the United States of America and Britain found that creativity was significantly related to divergent thinking and hence can be used to measure creativity. Traditional measures of intelligence emphasise convergent thinking. That is, logical reasoning towards single right answers. Measures of creativity call for new ideas, an original or unconventional response and breaking away from the beaten path.

Dunbar (1999) argues that most researchers see scientific creativity as being composed of the same mental processes that guide all other forms of creativity. The difference in science is one of the vast theoretical, technical and experimental knowledge that creative scientific ideas must either extend or more rarely supplant. There are sets of norms and scientific practices that any new discovery must abide by before other scientists accept it as being a discovery. This study focused on meanings of creativity that have relevance to science education.

2.2 Creativity and Intelligence in Relation to Subject Knowledge.

Various scholars have investigated the relationship between creativity and intelligence. Getzel's and Jackson (1962) investigated it using two groups from a population. In one group the pupils had high I.Q but low creativity scores while the other group had pupils with low I.Q but high creativity scores. They then administered school achievement tests and found no significant difference in the scores of the two groups.

Barron (1969), Mackinnon (1968) and Roe (1965) have all mentioned that there is a threshold effect for I.Q, such that above a certain level required for the mastery of a field, I.Q is not correlated to creativity. Mackinnon (1968) argued further that a mature scientist with an adult I.Q of 130 is as likely to win a Nobel Prize as one whose I.Q is 180. It is therefore clear that a creative individual is intelligent to a reasonable extent. That is intelligence is required for one to be able to organise his/her ideas to make any productive contribution to his/her field of study.

Cropley (1966) using an unselected group of children carried out a similar study. He used two tests, one for intelligence and the other for creativity, which he factor, analysed. From his findings he concluded, that, it was unacceptable to think of creativity as a separate basic intellectual mode. Lovel and Shields (1967) in their study came to the same conclusion as Cropley concluding that an intelligent pupil is creative to different degrees according to the task set before him. Freeman *et al* (1971) summarises the relationship between intelligence and creativity by stating that creativity overlaps very considerably with intelligence as assessed by conventional tests.

Arlin (1974) showed that differential formulation of problems is systematically related to other aspects of human thought. She found that the higher the stage of cognitive development in Piaget's (1970) terms, the higher the quality of the problem that is formulated. Dunbar (1999) supports this further by stating that analogy is one of the most widely mentioned psychological processes that enhance scientific creativity. He explains further that analogy has two components – the target and the source. The target is the concept or problem that the scientist is attempting to solve or explain while the source is another piece of knowledge that the scientist uses to understand the target. So the scientist maps the features of the source into the features of the target and in the process new concepts are discovered and a scientific discovery is made. This shows that subject knowledge is a pre-requisite for creative production in science. Basic level of intelligence is needed also for one to be creative, that is, a core with which to work with (McMahon & McMahon, 1982). All the above-discussed studies have been done outside Kenya; therefore there were needs to find out the situation in our Kenyan schools. The study focused on knowledge and how it relates to scientific creativity.

2.3 Categories of Psychological Meanings of Creativity.

Okere (1986) has summarised the psychological meanings of creativity under the following headings: sensitivity to problems, recognition of relationship, flexibility in reasoning and planning for investigations.

2.3.1 Sensitivity to Problems.

Guilford (1950) predicted this trait of sensitivity to problems. He later pointed out that this factor belongs to the general categories of evaluative abilities (Guilford, 1957).

Torrance (1959, 1960, &1962) defined creativity as the ability to be aware of problems, think of possible solutions to the problems and test the practicability of these solutions. Bartlet (1958) and Parnes (1963) pointed out that a competent research scientist is one who is capable of identifying problem sites that require concentration, and then defining the problems appropriately for creative attack. Einstein and Infed (1938) remarked that for one to raise new questions, new possibilities, to regard old questions from a new angle, require creative imagination. Wertheiner (1945) generalised this point, by asserting that the function of thinking is not just solving an actual problem, but discovering, envisaging and going into deeper questions.

2.3.2 Recognition of Relationships.

Another factor that constitutes creative ability is recognition of relationships. A creative individual should recognise relationships among concepts and retrieve earlier experiences whenever he/she encounter's a new situation (Rogers, 1954). Okere (1986) further explains that in science this description could apply to a student who can recognise relationships between every day phenomena and the concepts and ideas he has acquired from the science lessons. Hence, a student should be able to generate hypotheses regarding the causes of given phenomena or observations from one topic or from several topics. Brunner (1957,

1963) argues that a creative individual should not see data as unique but as part of related sequence of events, which the environment has been providing.

Wallach and Kogan (1965) carried out some work on American children by sorting out a sample of 151 fifth grades. They grouped them into two groups high and low creativity groups, and high and low I.Q groups. They then obtained scores from them on a number of cognitive variables of which category width of data coded was one. They found that there was significant tendency for the more highly creative individual to get high scores on the category width test.

2.3.3 Flexibility in Reasoning.

Guilford (1950, 1967) hypothesised that creative thinkers are flexible thinkers. They readily desert old ways of thinking and strike out in new directions. According to Wilson, *et al* (1954) there are two types of flexibility. Spontaneous flexibility is one of them. It is the ability to produce a great variety of ideas, with freedom from inertia. The second type is called adaptive flexibility, which facilitates the solution of problems.

According to Kuhn (1959, 1970) flexibility is limited to a specific discipline and hence the amount of subject knowledge that a scientist has at hand. According to Okere (1986) flexibility in science education can be assessed in solving a design problem where students may suggest different approaches in evaluating a dependent variable or a problem requiring generation of hypothesis using different topics.

2.3.4 Planning for Investigation.

According to Parnes (1963) and Hudson (1967) this ability can be displayed in problems that require students to propose and devise experiments to test hypothesis. As noted by Okere (1986) there is no much empirical data on planning for investigation.

2.4 Scientific Meanings of Creativity.

According to Okere (1986, 1996), the above psychological meanings of creativity have relevance to science education. The mapping of the psychological definitions onto science process skills is displayed in his model given below.

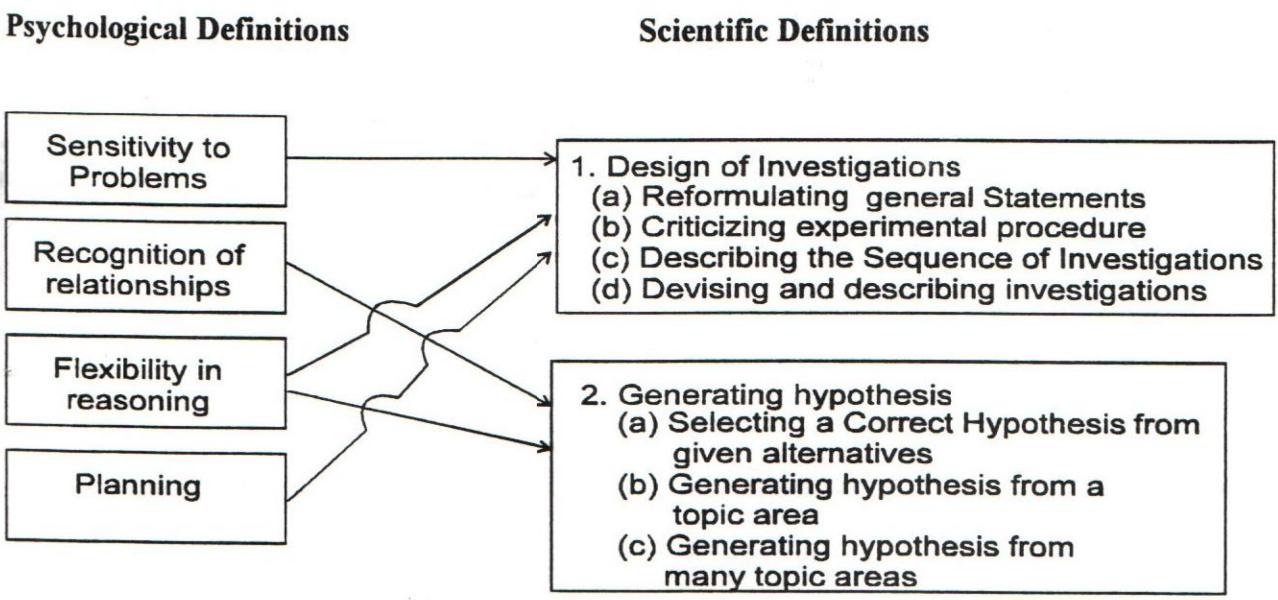


Figure 1. The mapping of psychological definitions of creativity onto scientific meanings

Source. Okere, 1986.

2.4.1 Design of Investigations.

2.4.1.1 Reformulating General Statements.

In this case a student should be able to rephrase statements in such a way that they could be checked scientifically. This means that a student should first be able to identify the inadequacy of a given statement and also suggest an experiment that could be used to check the rephrased statement and state the control variables.

2.4.1.2 Criticizing Experimental Procedures.

In this case a student should be able to identify what is wrong with an experimental procedure. This means that a student should be able to identify the variables that need to be controlled to make the results of the investigations fairer. A student should also be able to explain the need to control such variables.

2.4.1.3 Describing Sequences of Investigations.

Here a student should be able to describe a given experiment that would be used to investigate a particular problem. In doing this, a student describes the sequences of investigations and explains the criteria to be used in determining the dependent variable.

2.4.1.4 Devising and Describing Investigations.

Here an outline of an experimental procedure to be followed is not given, hence, a student is expected to decide what experimental procedure to use

2.4.2 Generating Hypothesis.

2.4.2.1 Selecting a Correct Hypothesis from given Alternatives.

Here a student should be able to select a correct hypothesis from given alternatives. This will require a student first to recognise relationship between particular biology concepts and the expected outcome before selecting the correct hypothesis, Also a student should be able to give reasons for whatever choice they make.

2.4.2.2 Generating a Hypothesis from a Particular Topic area.

In this case a student suggests causes of given physical phenomena or described observations. This will require a student to generate a hypothesis based on particular topic and give reasons for deciding on the particular hypothesis.

2.4.2.3 Generating hypothesis from Many Topic areas.

Here problems elicit many possible hypotheses from various science topics when explaining causes of observed phenomena.

In the current study the focus was on the assessment of the above skills among form three biology students of Nakuru district.

2.5 Stimulating Creativity.

More and more research projects have been pointing out the part that education can play in the development of creative efficacy. At the University of Chicago, the studies of Getzels and Jackson (1958) have found that, among bright students, the most highly creative ones excel in achievement to as great a degree as do the highest I. Q. students. Torrance of the University of Minnesota (1959) corroborated these findings in his work. This finding kindled interest in creative performance as criteria in the selection of 'gifted' children, a supplement to the traditional criteria of I.Q. and teachers preference. Torrance (1961) argues that; perhaps the most promising areas if we are interested in what can be done to encourage creative talent to unfold, is that of experimentation with teaching procedures which will stimulate students to think independently, to test their ideas and to communicate them to others. Collete, and Chiappetta, (1994) and National Research Council (1996) argue that all students can learn science, and they learn best by doing, since science is a way of knowing, a way of investigating a body of knowledge and attitude hence has empirical nature. This means that students should be taught how to do science, to find answers for themselves not simply to engage in the memorisation of facts. They go further to argue that many secondary school students are concrete thinkers and must have concrete experiences if they have to be successful in learning science.

Teachers' role in secondary school classroom should serve as guides and facilitators of learning. To teach 'good' science, teachers must be able to establish an environment that is learner centred, that facilitates collaborative as well as independent learning, that encourages taking risks, that fosters problem solving and critical thinking (National Research Council (1996). They quote Piaget's summed up role of the teacher, as "Telling is not teaching". They further point out the place of science in the students' lives by stating that all students can learn science and all should become scientifically literate.

According to Taylor (1959) creative productivity can be developed by deliberate procedures. Guilford (1952) argues that, creative activity probably represents to some extent many learned skills, there may be limitations set on these skills by heredity, but convinced that through learning one can extend the skills within those limitations. This is supported further by Davis (1974) who points out that authors research with 6^{th}, 7^{th}, and 8^{th} grade students have shown that students can be taught to hunt for new problem approaches and to value original thinking. A student awareness of the importance of creative innovation in the larger world and his own life can be increased. At Buffalo University one research project has revealed that on five of seven measures of creative ability, the students who had taken the one semester course were significantly superior to the group of matched control subjects who had not taken the course. The former group also showed significant gain on a scale derived to assess factors of leadership ability, dominance, persistence and social initiative (Meadow & Parnes, 1959). The second part of this study examined the persistence or carry-over effects of the creative problem-solving course. Results indicated that the improvement in creative productivity persisted for more than eight months after completing the course (Schmadel, 1960). Criteria used in evaluation of the ideas produced included both uniqueness and usefulness. James (1960) of the University of Chicago has conducted several research projects on the effects of teaching creative problem solving to governmental and industrial administrators.

Crutchfield (1966) used creative problem solving techniques to train a group of children. Another group of children acted as the control group. He found that the trained children surpassed those in the control group by far in asking questions, sensitivity to discrepancies, generation of many good ideas and utilisation of clues and getting an idea that gives an actual solution. Sommer (1961) reported further that mastery of subject matter increased along with creative ability scores as a result of weaving creative problem solving into existing courses. This indicates that problem solving does enhance creativity. Langley *et al* (1987) and Dunbar (1999) support this when they argue that creativity in the context of scientific discovery is a form of problem solving. Langley *et al* (1987) further argues that finding problems and formulating them involves the same underlying cognitive processes of heuristic search and sub-goal generation as any other kind of problem solving behaviour. Dunbar and Klahr (1988) proposed that scientific thinking could be thought of as a search in both a hypothesis and an experimental space.

According to Standler (1998), Sternberg's theory of creativity, many environments discourage creativity. He goes further to argue that many schools have a standard orthodox one right way approach to the material. A student who does it differently from the instructor is labelled 'wrong'. This tends to discourage creativity.

Yager (1999) remarks that most science curriculum developers view a science program as something to be done to students to help them learn a given body of information. Little formal attention has been given in science programs to the development of student's imagination and creative thinking, which are basic ingredients for science. Morarcsik (1981), Brandt (1986) and Amibile (1989) points out that little has been done purposely to incorporate the creative dormain into science programs.

Barrons and Elia (1998) point out that teacher's belief about teaching science as telling science, instead of teaching a process, science as a way of thinking. Kouladis (1987) found that science teacher pedagogical positions are quite traditional, giving great emphasis to presentation of knowledge. This does not encourage learners to be creative. Jennings (1980) argues of the pressures of timetable and examinations that focus the attention on the syllabus to be covered. This tempts teachers towards transmission of information supported by dictated notes instead of learner's understanding of both the content and processes of science.

Freeman *et al* (1971) have stated that creative development can be enhanced through the use of discovery methods. Sommers (1961) found in industrial arts training that using discovery methods may lead to superior performance in subject matter as well as gain in creative productivity. A study by Worthen (1968) on discovery method on learning of Mathematics was found to be superior to expository methods in retention in the transfer of heuristics behaviours valuable in creative performance.

Osborn (1953) argues about brainstorming, which is used to facilitate the expression of the preconscious imagination in a group situation by deferring conscious critical evaluations. Treffinger *et al* (2000) also talks of use of brainstorming as one tool in creative problem solving to help in generating many ideas. Parnes and Meadow (1959), and Osborn (1953) argue that brainstorming is a method whereby a subject is instructed to attempt to solve problems by recording all tentative solutions, which occur to one, postponing judicial evaluations of those solutions to a subsequent time period. A study by Parnes and Meadow (1959) on effects of creative problem solving (by untrained subjects) of instructions to express solutions without evaluation (brainstorming) and instructions which required only solutions of good quality (non-brainstorming) resulted in two main findings. One is that more quality ideas were produced under brainstorming and secondly under brainstorming students produced a significantly greater number of good quality ideas than in non-brainstorming. Dunbar (1995, 1997, & 1999) supports the importance of brainstorming further. He investigated a group of scientists reasoning at lab meetings in "vivo" and found that much of their creative aspects of science such as the generation of new concepts and theories take place in groups and that the reasoning in these creative moments is distributed over individuals rather than residing in one individual. He also found that the composition of the group could have radical effects on distributed results in different representations of an issue being generated, allowing the scientists to look at problems from multiple perspectives.

From the above discussion, it shows that creativity can indeed be taught and learned in schools. Garfield (1989) quotes Leopold (1978) pointing out that the creative process is at least partly the consequence of trained or honed skills. He further argues that, since skills that can be learned can also be taught, then the art of scientific thinking can be taught by allowing students to experience all the thrills and missteps of an actual scientific research program or experiment. He further argues that, "if scientific creativity is a set of skills that can indeed be taught then we must not only provide the teachers but the environment in which such skills can be learned, used and nurtured. If we persist in teaching the façade of science, instead of its realities, then the pressure-cooker, cookie-cutter research programs that seem to be more and more prevalent today will not just be the harbingers of the future of science, but also its death".

All studies on stimulating of creativity in students have been done in the western countries. Okere (2000) in his study, the status in Physics teaching and examining in Kenyan Secondary Schools, involving 87 teachers in Machakos district, found that most teachers use demonstration and lecture (33.3 %). Only 9.5% use project method and none used field trips. Their approaches in the teaching of science cannot help develop the creative skill. The present study explored whether the learning opportunities provided by biology teachers do enhance the acquisition of scientific creativity skill in students.

2.6 Gender and Scientific Creativity.

Quantitative review of gender differences in school science achievement, all reveals significant gender differences in science achievement (Steinkamp, & Maehr 1983, 1984). Most studies done on gender differences in school science achievement conclude that boys generally perform better than girls especially in the science practical (Eshiwani, 1986). This was attributed to lack of confidence in handling of equipments, tools and materials (Eshiwani 1986). However, Mondoh (1986) found that there was no significant difference between boys and girls in performance of some mathematical concepts.

A study did by Otieno-Alego (1991) on competence of junior secondary pupils on some science process skills, namely, observation, prediction, generalisation and control of variables, showed that boys performed significantly better than girls. On open-mindedness, boys were relatively more competent than girls. However all had low levels of open-mindedness. In overall tests, boys performed better in control variables and predictions.

According to Murphy (1991) the cross cultural uniformity of gender differences in science achievement suggests that cultural factors alone cannot account for them. This was due to the fact that a study done by International Association for the Evaluation of Educational

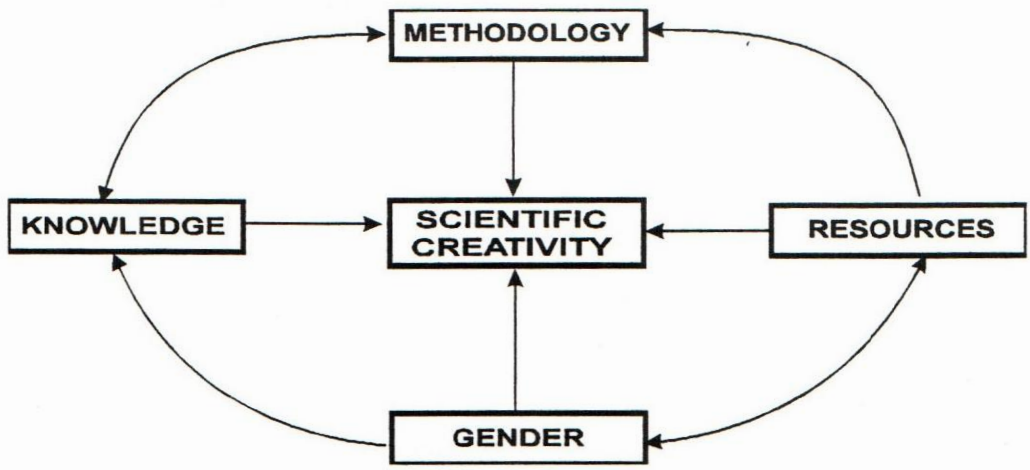
Achievements (IEA) and National Assessment of Educational Progress in United States showed that boys were ahead of girls in achievement in all sciences.

Some theories have been put forward to explain the gender differences in science achievement. According to Fee (1981) and Kellen (1982) scientific theory practice and approaches may reflect a masculine approach to the natural world. Hence the teaching of science in the lecture, classroom and laboratory may reflect that perspective. Rosser (1993) says that article titles written by and about women in science suggest that women who do become scientists are frequently viewed as anomalies or face numerous problems and difficulties because of their gender. All the studies are tendering towards achievements. In this current study scientific creativity in biology was explored to find out whether it is gender dependent.

2.7 Conceptual framework.

Okere's model (Okere, 1986) given on page 20 was used to test level of scientific creativity Full description of the model has also been given on page20 section 2.4.This model guided the study in developing test items to measure scientific creativity and the observation schedule.

The model below shows how variables under study may affect scientific creativity.



<u>Figure 2.</u> Model showing how variables under study may affect scientific creativity.

The single – directional arrows from the variables to scientific creativity indicate that creativity may depend on the teachers' methodology, resources available, students' knowledge level and gender.

The two – way arrows indicate that some interaction may occur and in turn affect creativity i.e. between gender and resources, knowledge and methodology.

The single directional arrows between the variables shows how one variable may influence the other, i.e. resources available determine the methodology used by the teachers and knowledge level may be gender dependent.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction.

This chapter discusses the research design used in the investigation, the target population, sampling procedures, types of instruments used and then validation procedures. Data collection procedures and data analysis techniques are also discussed. Due to the nature of the investigation, both qualitative and quantitative methods were used.

3.2 Research Design.

This study aimed at investigating the effects of gender, knowledge and learning opportunities on scientific creativity amongst form three biology students. Descriptive research design was used in this study. This design was found to be appropriate since it could be used to determine the nature of prevailing conditions or relationships and practices that exist (Cohen & Manion, 1987). The methods used in this study were the cross section survey and observation case study. Cross – section survey method was used in this study since the information to be collected is drawn from predetermined population (Borg & Gall, 1989). Its main purpose is to explore and describe the variable under the study (Kathuri & Pals, 1993, Cohen & Manion, 1987). This survey method was also found to be appropriate because it has an advantage of collecting a lot of information in a relatively short time. In this study, data was collected from learners by the use of two tests, i.e. the biology achievement test (BAT) and the biology scientific creativity test (BSCT).

A case study was also used to observe learning opportunities provided during biology lessons. Cohen & Manion (1987), Borg & Gall (1989) point out that the purpose of a case study is to observe the characteristics of an individual unit, probing deeply and analysing intensively the phenomena with a view to establishing generalisations about the wider population to which that unit belongs. Hence, the method was used to get in-depth information about the nature and quality of classroom interactions in form three biology lessons.

3.3 The Target Population and Accessible Population.

The study focused on learners in boys, girls and mixed public secondary schools in Nakuru district. The accessible population from which the study sample was drawn was the form three biology students in the boys, girls and mixed public secondary schools in Nakuru district. School administrators could not allow the use of form four classes being an examinable class. Form three was found appropriate because they had covered enough content in biology for the purpose of the research. The sampling procedures that were used are detailed below.

3.4 Sampling Procedure.

3.4.1 Selection of Participating Schools.

The focus was public secondary schools. First, a list of all public secondary schools in Nakuru district was obtained from the District Education office. The schools were already categorised as mixed schools, girls' schools, or boys' schools. The schools in each category formed a sampling frame. Using Stratified random sampling method, two schools from each category of boys and girls' and four from mixed, were selected. This gave a total of eight schools, two from boys and girls schools and four from mixed schools.

3.4.2 Selection of the Participating Streams.

Two girls', two boys' and four mixed schools were selected and used in this study. The selection of the form three streams whose learners were the subjects of the study was done using simple random sampling procedure, since the schools had more than one stream for each class. One stream from each school was selected using simple random sampling procedure.

On the basis of the class size of 40 students approved by the ministry of Education, it was expected that a total of 320 students would form the sample of this study. It was however, realised that some of the sampled schools had more than 40 students per stream, while others had less than 40. The total number of students in form three streams that were sampled in this study in all the eight schools was 363 learners.

3.4.3 Selection of Streams for Observation.

Out of the eight streams sampled, three streams were selected using simple random sampling procedure, one from each stratum of boys', girls' and mixed. These three streams were observed during biology lessons. 8 lessons were observed in each school, with one being a practical lesson. A total of 24 lessons were observed, out of these 21 were theory and 3 were practical lessons.

3.5 Instrumentation.

In this study three instruments were used. These are

(i) Biology Achievement Test (BAT)

(ii) Biology Scientific Creativity Test (BSCT)

(iii) Biology Observation Schedule (BOS)

The purpose of using these instruments is explained in sections 3.5.1 to 3.5.3.

The biology achievement test (BAT) items were adapted from the Kenya certificate of secondary education (KCSE) national examination papers. Items in the biology scientific creativity test were adapted from the assessment of performance unit (A.P.U) of UK tests (APU, 1982, 1983). The research instruments were pilot tested in two schools in Nakuru district. Following the pilot study, the instruments were validated and their reliability estimated before being used for the main study. Details of the validation procedures and estimation of reliability are given in sections 3.5.1 to 3.5.3.

3.5.1 Biology Achievement Test (BAT).

The BAT (Appendix 1) was aimed at assessing learners' knowledge of biology content. The test items were drawn from the same topics as those of BSCT. The BAT had 24 items selected from Kenya Certificate of Secondary Education (KCSE) National Examination Papers. All the items were open-ended.

After careful editing by the researcher, the BAT was given to a specialist in biology education, who helped to moderate the BAT before it was piloted on 80 form three biology students in Nakuru district. On the basis of the pilot results, the BAT was validated. The procedure used to validate the test is out lined in the next section.

3.5.1.1 Validation of the BAT items.

3.5.1.1.1 Item Analysis.

The test was scored on the basis of one point for each correct response. Anastasi (1982), Mulder (1989), and Lokeshkoul (1992), give difficulty index of the item and discriminating index as the criteria for selecting the items. Difficulty index expresses the degree of difficulty or easiness of an item while the discriminating index expresses the ability of an item to discriminate between poor and good students. The results obtained from the pilot study were used to compute the difficulty level and discrimination index for each of the items. The results are shown in table 1. The formula used to compute both the difficulty and discrimination indices for all the open-ended items are:

$$\text{Difficulty index} = \frac{S_H + S_L - 2N \times \text{Score}_{minimum}}{2N\,(\text{Score}_{maximum} - \text{Score}_{minimum})}$$

$$\text{Discrimination Index} = \frac{S_H - S_L}{N\,(\text{Score}_{maximum} - \text{Score}_{minimum})}$$

Where

S_H is the sum of scores for "high".

S_L is the sum of scores of " low".

N is 25% of the number tested.

$\text{Score}_{maximum}$ is the highest possible score on the item.

$\text{Score}_{minimum}$ is the lowest score on the item.

Noll, *et al* (1979).

Table 1: Difficulty Index and Discrimination Index of the Biology Achievement Test.

Item	Difficulty Index	Discrimination Index	Item	Difficulty Index	Discrimination Index
1	0.19	0.34	16	0.62	0.65
2	0.44	0.5	17	0.52	0.38
3	0.53	0.35	18	0.62	0.65
4	0.12	0.24	19	0.06	0
5	0.04	-0.04	20	0.35	0.57
6	0.35	0.53	21	0.35	0.56
7	0.25	0.38	22	0.37	0.44
8	0.88	0.12	23	0.77	0.35
9	0.62	0.27	24	0.41	0.29
10	0.74	0.06			
11	0.43	0.29			
12	0.04	-0.03			
13	0.17	0.21			
14	0.20	0.18			
15	0.54	0.5			

The difficulty level ranged from 0.04 to 0.77 while the discriminating index ranged from 0.03 to 0.65. For most testing purposes an ideal item should have a difficulty index of 0.40 to 0.60 and discrimination index of 0.2 or more (Lokeshkoul, 1992; Noll et all. 1979). However Anastasi (1982) argues that the appropriate difficulty level depends on the purpose of the test. She further argues that for a test testing mastery of skills or knowledge even very easy or difficult items yielding a low percentage of passing may be included. On the basis of difficulty index and discrimination index values shown on table 3a, above all items were included in the final BAT. Though items 1,4,7,13 and 14 did not meet the ideal difficulty index, they were retained and revised as they met the ideal discrimination index. Item 5, 12 and 19 had 0 or negative discrimination index and were carefully examined for ambiguities, inaccuracies and other errors as advised by Lokeshkoul (1992). They were revised with the help of experts in biology education and retained. Mulder (1989) argues that difficulty and discrimination indices are not the only criteria for deciding the appropriateness of an item. Certain items can be retained if they deal with an important aspect of the field of investigation. In this case, BAT items were from the same content as the BSCT. Since the reliability of the test items was high all items were retained. Those that did not meet the criteria were revised and this helped to improve the overall reliability of the test.

3.5.1.1.2 Reliability of the BAT.

The BAT items were not dichotomously scored. Ebel and Frisbie (1991) and Borg and Gall (1989) recommend the use of Cronbach's coefficient alpha to estimate the reliability of such instruments. The coefficient alpha was 0.72 for the test. This reliability coefficient falls within acceptable limits for teacher made tests of 0.5 (Ebel, 1972).

3.5.2 The Biology Scientific Creativity Test (BSCT).

The biology scientific creativity test (BSCT) was aimed at assessing learners' competence in scientific creativity skills, which include, recognition of relationship, flexibility, sensitivity to problems and planning of investigations, in biology. The items were drawn from form one to form three topics in biology covering the same content as the BAT. The scientific creativity aspects covered in the test were sensitivity, planning, flexibility and recognition of relationships. These map onto the scientific meanings of scientific creativity (Fig.2.1, page 20). These skills guided the development of the items in the test. The BSCT had 13 items adapted from the A.P.U. tests. All items were open-ended. Each item tested different aspects of scientific creativity. The test was piloted with 80 form three biology students in the two pilot schools in Nakuru district. The adapted test items had shown high correlation with Torrance's creativity test (Okere, 1986).

3.5.2.1 Validation of the BSCT items.

A specialist in scientific creativity as well as science education moderated the BSCT items and the scoring key before piloting. The test was then piloted on 80 form three biology students in the pilot schools. After the pilot study, some of the items were revised, and retained in the final test.

3.5.2.2 Reliability of the BSCT.

The BSCT items were not scored dichotomously. Cronbach's coefficient alpha was used to estimate reliability of the items. The coefficient was 0.60. This reliability coefficient falls within acceptable limits for teacher made tests of 0.5 (Ebel, 1972).

3.5.3 The Biology Observation Schedule (BOS).

One of the methods used in qualitative research is systematic classroom observation of the teaching-learning activities taking place during classroom instruction. In this study the researcher opted to be a non-participant observer because it minimises interactions with the subjects and attempts to obtain as complete a record as possible of behaviour relevant to the observer's interest (Borg & Gall, 1989).

An effective science lesson has been described as one in which the style of learning necessarily casts the teacher in the role of manager of learning experiences and as a partner in learning with the pupils (Jennings, 1980). Mestre (2000) explains that science is a process of inquiry that allows us to ask answerable questions, to design methods for answering the questions and to organise our answers under a few powerful principles. In view of this, effective teaching thus should encourage active participation in the lesson even for them to acquire scientific creativity skills. In view of this, it was found necessary to have direct observation of the intellectual behaviour in biology lessons for this study. Direct biology lessons' observation was useful for probing deeply and analysing intensively the nature and quality of teacher-learner interactions with the aim of generalising on the learning opportunities provided in biology lessons.

The biology observation schedule (BOS) developed by the schools council project for the evaluation of science teaching methods (Eggleton, *et al*, 1976) was adapted. Its authors report that it was used to observe over 400 science lessons and was found to suit the purpose of this study. It was developed with the aim of facilitating the recording of activities that are associated with science teaching and learning as well as scientific creativity.

This tool had five broad categories as follows

(a) Nature of teacher's questions

(b) Nature of teacher's statements

(c) Nature of teacher's sources of information to the learners

(d) Nature of learner to learner interactions

(e) Nature of learners' questions to the teacher.

Each of these categories was further classified into more specific behaviours (see appendix 3).

3.5.3.1 Validation of the BOS.

A pilot study was conducted in which two form three biology teachers were each observed teaching on two occasions. Inter-observer agreement 62% to75% was achieved between the researcher and an experienced science education researcher in all specific behaviours. This was found to be satisfactory as Borg and Gall (1989) give an inter-observer agreement of 70% and above as ideal. This gave a consistency, which would be achieved with most behaviour. The formula used to compute the inter-observer reliability is

$$\text{Percentage of agreement} = \frac{2 \times \text{no. of agreements}}{\text{Total no. of observations}}$$

(Monette et. al., 1990).

3.5.3.2 Observation of Biology Lessons.

The BOS was used to observe a total of 24 form three biology lessons in the three sampled schools. In each form three class at least eight lessons were observed, with at least one being a practical lesson. The researcher sat in the classroom during a biology lesson and recorded the intellectual behaviours on the right hand side of the BOS by tallying against each specific behaviour as it occurred (see appendix 3). This continued for the entire period of the lesson, which ranged between 40 minutes for a single lesson and 80 minutes for a double lesson. The frequency of each specific behaviour was calculated as a percentage of all the behaviours within all the categories. The results obtained are discussed in the next chapter.

3.5.4 Administration of the instruments and Data Collection Procedures.

Before the administration of the research instruments, the researcher obtained research permit from the Ministry of Education headquarters', Nairobi. The researcher then presented the permit to the Nakuru district education officer before commencement of the study.

After sampling the schools to be used in the study, the Nakuru district education officer prepared an introductory letter for the researcher to introduce her to school authorities. The schools were visited before the commencement of the study to explain the purpose of the study to the head teachers. The head teachers introduced the researcher to the form three biology teachers' and the form three students. The researcher then organized with the respective teachers on test taking and observation of the biology lessons.

The researcher administered the BAT and the BSCT with the assistance of the biology teachers in the sampled schools. A total of 363 students took the tests. In the BAT, the scores of all items were added up together and converted into a percentage. They were then correlated with those of the biology scientific creativity test. The results are presented and discussed in chapter four. In the BSCT, each item was scored differently and measured different aspect of scientific creativity. All the scores were added together and converted to percentages and then correlated with the biology achievement test. Using the percentage scores of BSCT, t-test and one-way ANOVA statistical techniques were used to find out whether there was any significant difference in achievement of the BSCT and gender, and BSCT and category of schools respectively. The results are presented and discussed in chapter four. The BSCT percentage scores were then categorised as either high or low level with a criterion of 40%. Chi-square statistical technique was used to find out whether the level of scientific creativity was gender dependent and if there was any relationship between level of scientific creativity and school category. The same procedure was repeated for each aspect of scientific creativity. The results are presented and discussed in chapter four.

3.6 Methods used in Data Analysis.

Both qualitative and quantitative methods of data analysis were used since the study generated both qualitative and quantitative data.

Analysis of the observations of biology lessons and the scientific creativity test was done qualitatively. The qualitative responses on the BSCT were later quantified and the resulting data used for further analysis. The statistical package for social sciences (SPSS) computer package was used to analyse quantitative data. The Pearson Product Moment Correlation Coefficient (PPMC) was used to analyse the correlation between the learners' scores in the achievement test and the biology scientific creativity test. Chi-square was used to determine if the level of scientific creativity was gender dependent. t-test was used to compare mean scores of learners by gender and school category on the biology scientific creativity test. One-way ANOVA was used to compare the mean scores of learners from different school categories on the biology scientific creativity test. Descriptive statistics was used to describe the distribution of scores in the biology scientific creativity test using means, standard deviations and percentages. Table 2 shows in summary the statistical techniques used for analysing both the qualitative and quantitative data.

Table 2: Summary of the Methods used in Data Analysis.

Objective	Hypothesis	Method used for Data Analysis
To describe the level of scientific creativity among form three biology students.		Descriptive statistics (percentages).
To determine if there is any relationship between learners' level of scientific creativity and knowledge in biology.	Ho_1: There is no significant relationship between the learners' level of scientific creativity and knowledge in biology.	Pearson Product Moment Correlation Coefficient between learners' scores on the biology achievement test and the biology scientific creativity test
To determine if the learners' level of scientific creativity in biology is gender dependent	Ho_2: There is no significant relationship between the learners' level of scientific creativity in biology and gender	Compare categorised scores on the biology scientific creativity test by gender using Chi-square.
To determine if there is any difference in learners' performance in biology scientific creativity test by gender.	Ho_3: There is no significant difference in learners' performance in biology scientific creativity test by gender	Compare the means scores of learners by gender on the biology scientific creativity test using t-test.
To determine if there is any relationship between learners' level of scientific creativity in biology and school category	Ho_4: There is no significant relationship between learners' level of scientific creativity in biology and school category.	Compare learners' categorized scores on the biology scientific creativity test by school category using Chi-square.
To determine if there is any difference in learners' performance in biology scientific creativity test by school category.	Ho_5: There is no significant difference in learners' performance in biology scientific creativity test by school category.	Compare the mean scores of learners from different school categories on the biology scientific creativity test using One-way ANOVA.
To find out if teachers provide learning opportunities that encourage scientific creativity in biology		Descriptive statistics (Percentages)

CHAPTER FOUR

RESULTS, INTERPRETATION AND DISCUSSION

4.1 Introduction.

Both qualitative and quantitative data was obtained and the results are presented in this chapter. Specifically the results are presented according to each objective and hypothesis as outlined and discussed below.

4.2 Biology Scientific Creativity Test.

4.2.1 Introduction.

The students' level of scientific creativity was assessed using the biology scientific creativity test (BSCT). The BSCT comprised 13 test items adapted from the APU test items that were widely used in the assessment of pupils' competence on science process skills in England and Wales (A.P.U 1982,1983). The items used had shown high correlation with Torrance's creativity test (Okere, 1986). Aspects of scientific creativity tested were flexibility, recognition of relationships, sensitivity and planning.

4.2.2 Students' Responses and Performance on the Biology Scientific Creativity Test.

Students' responses to each item in the biology scientific creativity test were analysed. The performance of each item is also shown by gender.

Question 1: Grasshoppers attract their mates by using sound. Peacocks attract their mates using colour. Suggest four possible reasons why grasshoppers use sound rather than colour.

Table 3: Expected Responses for Question 1.

Responses
1. Bright colours would make grasshoppers more visible to their predators/camouflage
2. Sound can be detected at greater distance than colour
3. They are colour blind/poor sighted/blind.
4. Have well-developed hearing mechanism than sight
5. Have mechanisms for making characteristic sound
6. Mate only at night, cannot see colour at night

This item tested two aspects of scientific creativity, flexibility and recognition of relationship. Flexibility is giving more than one correct response. Those who gave two correct responses were awarded one mark for flexibility. Those who gave three correct responses scored two, while those who gave four correct responses scored three marks. The maximum score on flexibility was three marks. Recognition of relationship is recognising relationships among concepts tested in the item. For every correct response and fully explained relationship among concepts, the learner scored one mark. Maximum scofe on recognition was 4 marks.

Table 4: Correct Sample Responses from the Learners.

Response
1. Grasshoppers use their colour for protection, that is they look like grass, so the prey like the birds which are insect-eaters don't see it clearly
2. Grasshoppers have a better sense of hearing than the sense of sight
3. Grasshoppers can identify themselves more clearly by sounds because they produce a particular sound which other insects do not produce/distinct sound
4. Mating takes place at night and they use sound to trace one another

For each of the above-mentioned responses (table 4), the learner scored one mark for recognition of relationship, giving a total score of four marks. The total score on flexibility was three marks.

Some of the responses given by the learners were partially correct. They include the following:

Tables 5: Partially Correct Sample Responses from Learners.

	Response
1	Some are green in colour like grass hence cannot see each other
2.	Grasshoppers' compound eyes not sensitive like the peacock eyes to contain colours.
3.	Grasshoppers have a [illegible] hearing mechanism
4.	Sound can be heard even at night.

The total flexibility score for the responses in table 5 was three marks. The learner generated an idea that was partially correct. There was no score for recognition of relationships because the learner did not go further to show the relationship of the idea generated and the fact of grasshoppers using sound rather than colour. For example in the 1st response, the learner does not explain the importance of the grasshopper having the same colour as the grass.

Table 6: Incorrect Sample Responses from Learners.

Responses
1) They are too small to be seen in the grass
2) They are the same as the locusts, therefore difficult to identify them
3) They have compound eyes which makes it hard to attract their mates with colour
4) They are not primates and therefore cannot visualise colour changes

The responses given above in table 6 are incorrect because they have no scientific meaning. They have only mentioned the traits or characteristics of the grasshoppers like size, eye, but do not relate these traits to the role of mating.

The performance on this item was as given in table 7.

Table 7: Performance by Gender on Question 1.

	Flexibility				Recognition of relationship			
	Boys		Girls		Boys		Girls	
Score	No.	%	No.	%	No.	%	No.	%
0	105	59.7	129	69	70	39.8	107	57.2
1	54	30.7	45	24.1	72	40.9	55	29.4
2	13	7.4	12	6.4	27	15.3	24	12.8
3	4	2.3	1	0.5	6	3.4	1	0.5
4	_	_	_	_	1	0.6	0	0

From table 7, 59.7% of the boys and 69% of the girls scored zero marks in flexibility. This indicates that the boys are better than the girls in flexibility as per this item. The boys' and the girls' who scored zero in recognition of relationships are 39.8% and 57.2% respectively. This indicates that boys are better than the girls in recognition of relationship. From the table the data indicates that boys are better in generating ideas as well as recognition of relationship than the girls, as per this item

Question 2: Walking along the footpath shown in the diagram below (see appendix II), Thomas noticed that there was a morning glory plant growing on the trees, but only three quarters of the trunks. None of the trees had the morning glory growing on the side nearest to the footpath. Suggest at least four different reasons why the morning glory plant might grow only on some side of the trees.

The following table 8 shows the expected responses.

Table 8: Expected Responses for Question 2.

Response
1. Not so much light on the side shaded by the fence. Light required for photosynthesis.
2. Sun only shines on 3 sides of the trees. Sunlight required for photosynthesis
3. Too much sun on the footpath, which could dry up the plant.
4. People walking on the footpath knock off the plant
5. Wind blows hard on the footpath, causing excessive transpiration to the plant
6. Fungus found on the footpath
7. Vehicles on the main road provide things the plant likes e.g.CO_2 required for photosynthesis
8. Soil is poorer on the side of the footpath
9. May have been planted on only one side
10. May not have had time to grow on the other side.

NB. Any four correct response.

This item tested two aspects of scientific creativity, flexibility and recognition of relationship. Flexibility is giving more than one correct response. Those who gave two correct responses were awarded one mark for flexibility. Those who gave three correct responses scored two, while those who gave four correct responses scored three marks. The maximum score on flexibility was three marks.

Recognition of relationship is recognising relationship among concepts tested in the item. For every correct response and fully explained the relationship among the concepts, the learner scored one mark. Maximum score on recognition was four marks.

The following table 9 shows some of the correct responses given by the learners.

Table 9: Correct Sample Responses from Learners for Question 2.

Response
1. They may be destroyed by animals and human beings on the side of the footpath
2. Cars passing on the main road produce a lot of CO_2 which favours its growth
3. Side near the footpath has less light due to obstruction by mountains
4. Use soil near the footpath is hard due to people stepping on it /not fertile for the growth of morning glory

Table 10 gives some of the half or partially correct sample responses from the students.

Table 10: Partially Correct Sample Responses from the Learners for Question 2.

Response
1. Other sides are facing the direction the wind comes from
2. It will grow only on the side with less interference
3. Composition of the soil
4. People like picking it

Table 10 shows that learners who gave such kind of answers only scored marks for generating the idea i.e. flexibility. They did not score for recognition of relationship. This is because, in their answers they do not explain the relationship of the factor mentioned to the position the morning glory grows. For example, the answer that, "it will grow only on the side with less interference", the learner does not mention where the interference comes from.

The students gave incorrect responses to this question. Some of these responses are given in table 11.

Table 11: Incorrect Sample Responses from Learners for Question 2.

Response
1. Some plants have thorns that may pierce the morning glory.
2. Some plants have thick stems so it cannot coil itself around it.
3. Grow on some side as a means of support
4. Bernoulli's principle

The above responses (table 11) given by the learners are incorrect because they are not answering the question. They relate various content learnt in biology and physics but in the wrong content required to answer the question. For example Bernoulli's principle is learnt in physics but is not at all related to the question asked. The performance on this item (question2) is given in table 12.

Table 12: Performance by Gender on Question 2.

	Flexibility				Recognition of relationships.			
	Boys		Girls		Boys		Girls	
Score	No.	%	No.	%	No.	%	No.	%
0	89	50.6	132	70.6	66	37.5	96	51.3
1	49	27.8	41	21.9	49	27.8	53	28.3
2	31	17.6	12	6.4	37	21.0	31	16.1
3	7	4.0	2	1.1	21	11.9	6	3.2
4					3	1.7	1	0.5

Table 12 shows that 50.6% of boys and 70.6% of the girls scored zero marks on flexibility. This means that more boys' than the girls' performed better on flexibility. The boys' and girls who scored zero marks on recognition of relationships are 37.5% and 51.3% respectively. This means boys' performed better than the girls on recognition of relationships.

Overall boys are better both in flexibility and recognition of relationship than the girls as per this item. This was also the case on question one.

Question3: The diagram below (see appendix II) shows the way some animals and plants living in a canal depend on each other

(a) If there is a sudden drop in the number of Cyclops, what is likely to happen to the number of daphnia (water flea)?

(b) Give reasons for your answer.

Table 13 shows the expected responses

Table 13: Expected Responses for Question 3.

Responses	Flexibility	Recognition of relationship
(a) Increase/decrease	-	1
(b)(i) Decreased predation on duckweed and Canadian pond weed, hence increased food supply for the daphnia and increased predation by minnow or so number of daphnia likely to decrease	3	-
Total	3	1

Part (a) of the question was testing recognition of relationship on the feeding of the animals. If a learner recognised aspects of either increase or decrease in the number of daphnia, he/she scored one mark. Part (b) of the question tested flexibility. If a learner generated two ideas, they scored one mark. If three, scored two marks. If four, scored three marks. Maximum score on part (b) was three marks.

Some of the correct responses given by the learners are shown in table14.

Table 14: Correct Sample Responses from Learners for Question 3.

Response	Flexibility	Recognition of relationships
a) Decrease		1
b) Minnow feeds on shrimps that feed on Cyclops and bacteria. Bacteria would decrease and also the shrimps. Minno[illegible] like then feed on water fleas alone hence dec[illegible]	1	
Total	1	1
Or		
a) |Increase		1
b) A sudden drop in number of Cyclops would make the duckweed and Canadian pond weed number to increase service they are predated oven by only the daphnia which would in turn increase in number due to adequate food resource	2	
Total	2	1
Or		
a) Increase numerously and at the same time decrease		1
b) Duckweed and Canadian pondered which rise in number as they are being feed only by daphnia and small amount of Cyclops, thus daphnia increases. Minnow that use it feed on Cyclops through shrimps, and daphnia now feed, highly reducing it.	3	
Total	3	1

The total score a learner scored depended on the number of organisms he/she would mention that are in the food chains with both the Cyclops and daphnia. These would then be explained in relation to the question.

Some of the responses given by the learners were wrong. Examples are given in table 15

Table 15; Incorrect Sample Responses from the Learners for Question 3.

Incorrect response
1. a) They would decrease in number b) The duckweed will use more of the daphnia as the alternative Cyclops has reduced so the daphnia would be overused and decrease. Or
b) Daphnia will decrease reason duckweed will increase due to starvation and thus affect daphnia for it feeds on it. Shrimps decrease minnow starves and thus daphnia lack food, thus starves and dies

The answers given above in table 15 were incorrect because from their description, the energy flow is wrong. This indicates that the students' understanding of energy flow in a food chain and food webs is inadequate.

The following table 16 shows the performance of question 3

Table 16: Performance by Gender on Question 3.

	Flexibility				Recognition of relationship			
	Boys		Girls		Boys		Girls	
Scores	No.	%	No.	%	No.	%	No.	%
0	20	11.4	29	15	21	11.9	24	12.8
1	46	26.1	56	29.9	155	88.1	163	87.2
2	100	56.8	97	51.9	-	-	-	-
3	10	5.7	5	2.7	-	-	-	-

The results in the table 16 indicate that both boys and girls did well on recognition of relationship since more than half of the boys and girls scored all the points.

On flexibility 61.7% of boys and 54.6% of girls scored more than a half of the marks. This is unlike what has been observed on question 1 and 2 which the percentage of those scoring more than a half was 9 [illegible] for boys, 6.9% for girls and 19.6% boys and 7.5% girls respectively. Question 3 had classroom context, while question 1 and 2 had everyday context. This shows that context may affect level of scientific creativity in biology.

Question 4: Early one morning four containers were set up as shown in the diagram (see Appendix ii) the tops were airtight. They were left in a well- lit place for eight hours. After the eight hours, it was suggested that the water in two of the containers would have about the same amount of oxygen and also about the same amounts of Carbon dioxide as each other.

a) Do you agree or disagree with the suggestions

b) Give your reasons by stating what happens in each container.

The correct responses for this question are as shown in table 17.

Table 17: Expected Response for Question 4.

Response	Recognition of Relationship
a) Agree – 2 and 4 if balance assumed or disagree if balance not Assumed.	1
b) Container 1 – oxygen removed, replaced with Carbon dioxide (Respiration in fish)	1
Container 2 - oxygen removed by fish and plant replace with Carbon dioxide (respiration)	1
-Carbon dioxide removed by plant and replaced by Oxygen (photosynthesis) and respiration in plants.	1
Container 3 – Carbon dioxide removed, replaced with oxygen (net result of photosynthesis) and respiration in plants.	1
Container 4 – balance remains the same/ no change no organisms)	1
Total	6

NB ½ mark for each container if only one gas is referred and if process involved not mentioned

This question only tested on recognition of relationship.

Some of the correct sample responses given by the learners are shown in table18.

Table 18: Correct Sampled Responses from Learners for Question 4.

Response	Recognition of relationship
a) Yes, I agree container B and D.	1
b) Container 1, the fish use the oxygen in the container for respiration and give out Carbon dioxide. This increases the concentration of Carbon dioxide but reduces the oxygen concentration.	1
Container 2, the fish use up oxygen for respiration and give out Carbon dioxide, while the water plants use up Carbon dioxide, for photosynthesis and give out oxygen. This mountains the level of oxygen and Carbon dioxide in the water.	1
Container 3, the Carbon dioxide is used up for photosynthesis and oxygen is given off. This increases the oxygen concentration and reduces Carbon dioxide concentration.	1
Container 4, since there is no organism in the jar the level of Carbon dioxide and oxygen remains approximately the same hence it will have about the same amount of oxygen and Carbon dioxide as in B	1

NB. This learner missed one mark due to lack of full explanation on container 2 on plants also respiring.

Those who scored less than a mark for each container was due to failure to mention the gases involved and the processes involved by each of the organism present in each container. Some of the partially correct responses given by the learners are given in table 19.

Table 19: Partially Correct Sample Responses by Learners for Question 4.

Response	Recognition of relationship
The first two containers have more organisms as compared to the last tow. Container A has two fish which will breath in oxygen and often a while the oxygen will get finished, so do container B which has two fish and a plant. The amount of oxygen will be finished faster than even the first one as it has more organisms, which require oxygen. Container C will have less oxygen but in D the oxygen will remain the same, as there is no use of oxygen by an organism. Carbon dioxide in A and B will be the same but in C Carbon dioxide concentration will be decreased and in D it will be the same.	1

From the answer given above in table 19, learners do not conceptualise that the gases are dissolved in the water. They did not seem to understand the processes that take place in the organisms in the containers and the gases been exchanged.

The performance on question 4 is as shown on table 20

Table 20: Performance by Gender on Question 4.

	Recognition of relationship			
	Boys		Girls	
Scores	No.	%	No.	%
0	7	4.0	15	8.0
1	6	3.4	23	12.3
2	23	13	32	17.1
3	52	29.5	59	31.6
4	54	30.7	42	22.4
5	30	17.1	12	6.4
6	4	2.2	4	2.1

From the table 20, 79.5% of the boys scored more than half of the total marks. Only 62.5% of the girls scored more than half of the total marks. In both cases more than half of the students scored more than half of the total marks. The performance on the item is high, perhaps because the question was more classroom oriented requiring mainly what they have covered in the biology content. However the recognition required of content from more than one topic. Since the performance on the item was good, it means that learners can formulate hypothesis from many topic areas. Those who scored zero in this item did not attempt it at all.

Question 5:

The diagram below (see appendix ii) represents the apparatus that can be used to investigate an aspect of gaseous exchange in man.

i) Identify some errors in the set up that may hinder getting the expected results.

ii) Explain how you would improve the set up in order to get fair results.

In the above item part (i) was testing sensitivity of problems, while part (ii) was testing planning of investigations.

The expected responses and scoring for the above question are as given in table 21.

Table 21: Expected Responses for Question 5.

Response	Sensitivity`	Planning
i) a) Level of the limewater in both beakers full to the brim – no airflow and suck lime water instead when breathing in.	2	
b) All the delivery tubes in both beakers completely imm	2	
	4	
ii) a) Reduced the amount of limewater in both beakers to ½ or ¼ full		2
iii) b) Beaker A – delivery tube bringing air in should be immersed in the lime water while the one taking air to mouth by clip 1 should be above the lime.		2
Subtotal		4
TOTAL	4	4

The correct sample responses given by the learners are given in table 22.

Table 22: Correct Sample Responses from Learners for Question 5.

Response	Sensitivity	Planning
i) In beaker A, the tube from the mouth should not reach inside the water	1	
In beaker B, the tube to where the air is flowing should not reach the lime water	1	
ii) The beakers have been filled with lime water	2	
Subtotal	4	
iii) Fill the beaker to about half-then volume.		2
Ensure that the tube in beaker A that takes air to the mouth is not immersed in the lime – water and also that in beaker 2, which takes the air out of the beaker.		2
Sub total		4
Total	4	4

Some of the answers given by the learners were partially correct. This was because they did not mention the problems and corrections on both beakers and instead mentioned only one correction in one beaker, or they were not specific which beaker was been corrected. Examples of such responses are given in the following table 23.

Table 23: Partially Correct Sample Responses from Learner for Question 5.

Responses	Sensitivity	Planning
i) a) Lime water in beaker full.	1	
b) Delivery tubes immersed in the lime water	1	
Subtotal	2	
ii) a) Reduced the amount of limewater.		1
b) Reduced the size of the delivery tubes		1
Subtotal		2
TOTAL	2	2

Some learners mentioned only one problem of the delivery tubes on the amount of limewater and ended up scoring less mark.

Some of the responses given by the learners were incorrect. Examples of such responses are given in table 24.

Table 24: Incorrect Sampled Responses from Learners for Question 5

Responses	
i)	
	The clips are not tied
	Wrong direction of air flow
	The use of the mouth
	Presence of clips 1 and 2 which prevent any breath to get in the tubes
ii)	
	Tie the clips often putting the air inside
	The air should be from one source, the mouth and not from outside
	Should use the nose
	Remove the clips to let the air into the tubes

The responses given in table 24, shows that the learners are not very familiar with this kind of questions. Hence they pick an aspect of the set without understanding its role and the functioning of each set up in the experiment.

The performance on this item is shown in table 25 below

Table25: Performance by Gender on Question 5.

	Sensitivity				Planning			
	Girls		Boys		Girls		Boys	
Scores	No.	%	No.	%	No	%	No.	%
0	93	49.7	46	26.1	91	48.7	57	32.4
1	41	21.9	28	15.9	58	31.0	44	25.0
2	33	17.6	57	32.4	19	10.2	35	19.9
3	5	2.7	24	13.6	9	4.8	23	13.1
4	15	8	21	11.9	10	5.3	17	9.7

From table 25, 57.9% of the boys scored two and above marks on sensitivity while 42.7% scored two and above marks on planning. This shows that more boys could identify the problems in the set up but not all could state how to correct the problem.

28.3% and 20.3% of the girls scored two and above marks on sensitivity and planning respectively. This is far much lower than for the boys. This indicates that fewer girls than boys are sensitive and can be able to plan for an experimental set up.

Question 6: The following statement is not testable scientifically "Margarine is better for you than butter"

a) Explain why it is not testable

b) Rephrase the statement in such a way that it is testable.

Part (a) of the question tested sensitivity to problems while part (b) tested planning of investigations.

The correct response for the above question is given in table 26.

Table 26: Expected Response for Question 6.

Responses	Sensitivity	Planning
a) The term better is not measurable or cannot be checked scientifically	2	
b) E.g. Margarine has more fat or cholesterol than butter		2
Total	2	2

Some of the correct sample responses given by the learners are shown in table 27.

Table 27: Correct Sample Responses from Learners for Question 6.

Response	Sensitivity	Planning
a) This is because the term is not specific in terms of what e.g., nutritional value	2	
b) Margarine contains vitamins but butter does not		2
Total	2	2

Some of the incorrect sample responses given in question 6 are shown in table 28.

Table 28: Incorrect Sample Responses from Learners for Questions 6.

Responses
(a) It depends on one's taste, so cannot specify which one is better.
(b) Butter or margarine regarding your choice

The responses given above in table 28 show that learners' did not have an idea on what it means to have a scientifically testable statement. This is shown further by the performance on the item as shown in table 29.

Table 29: Performance by Gender on Question 6.

	Sensitivity				Planning			
	Boys		Girls		Boys		Girls	
Scores	No.	%	No.	%	No.	%	No.	%
0	166	94.3	174	93.0	149	84.7	159	85.0
1	9	5.1	13	7.0	22	12.5	26	13.9
2	1	0.6	-	-	5	2.8	2	1.1

From table 29, 94.3% of boys and 93% of girls did not score any marks for sensitivity while 84.7% of the boys and 85% of the girls did not score any marks on planning. This indicates that the item was poorly performed may be because this aspect is not taught in schools. Hence the learners don't know how to state a statement that can be scientifically tested and neither can they rephrase it to be testable scientifically.

Question 7: Some pupils wanted to run a test to find out if light is needed for the pond weed to go on glowing. They used four glass tanks full of pond water and planted pondweed in the sand at the bottom of each. When it was growing well they did this (see appendix ii). They need not have used all four tanks for their test.

a) Which one of the tanks(s) could they have used instead, to find the answers to their question?

b) Give reasons for your choice of tank(s)

Part (a) of the question was testing sensitivity, while part (b) was testing planning of experiments.

The expected response and scoring for the above question is given in table 30.

Table 30: Expected Response for Question 7.

Responses	Sensitivity	Planning
a) Tank 1 and 3	2	
b) Tank 2 – has drawbacks due to heating effects		1
Tank 4 – has drawback due to lack of air and complete darkness		1
Tank 1 and 3 – variables constant - Control experiment		2
TOTAL		4

The correct sample responses to question 7 are given in table 31

Table 31: Correct Sample Responses from Learners for Question 7

Responses	Sensitivity	Planning
a) 1 and 3	2	
b) Tank 1 would have acted as a control experiment so they require it.		1
Tank 2, there was no use of taking it because it was too much lights and heat from the bulb.		1
Tank 3, was necessary because all condition were there except light of which they were investigating.		1
Tank 4, they had derived the plant air by putting the plastic sheeting.		1
TOTAL	2	4

Most learners scored less than 2 marks for sensitivity because they either mentioned tank 1 or tank 3 and hence scored 1 mark, or they mentioned two tanks but only one was correct and the other wrong. For example tank 2 and 3, tank 2 is wrong while tank 3 is right and hence scored 1 mark.

Some of the part b question responses were partially correct. Sample responses are given in table 32.

Table 32: Partially Correct Sample Responses for Question 7.

Response	Planning
The first tank is left in the same conditions as before which allowed growth and one of those conditions is sufficient lighting while tank 3 is kept in a dark any cupboard rearing it does not get any eight and it would thus save as a control experiment.	1
Or	
I have chosen the tanks because of some reasons. The students want to investigate the importance of light. In tank 4, they have denied the plant with air putting the plastic sheeting. In tank 2, they have given too much light. So to get better results they could use tank 1 and 3, which have all conditions, and in 3 they deny light.	2

In the above sampled answers (table 32), part (a) was correct but most learners could not explain clearly why the choice of tanks 1 and 3 and why not 2 and 4. Most learners gave the expected results of the experiment in each tank instead of explaining their choice. Some of the incorrect sample responses given by the learners are shown in table 33.

Table 33: Incorrect Sample Responses from Learners for Question 7

Responses
a) Tank 2 and 4
b) Tank 2 is provided with light, tank 4 has no light because of the black plastic sheeting
Or
a) Tank 1and 3
b) Tank 3 will be dark hence the pond weed will die since it is not able to carry out the process of photosynthesis Tank 1 the pond weed will continue growing since there is diffused light coming from the sides of the lab.

In the second example (table 33), part (a) of the question is correct while part (b) is wrong. The performance on the item is as shown in table 34.

Table34: Performance by Gender on Question 7.

	Sensitivity				Planning			
	Boys		Girls		Boys		Girls	
Scores	No.	%	No.	%	No.	%	No.	%
0	46	26.1	54	28.9	130	73.9	130	69.5
1	86	48.9	95	50.8	34	19.3	48	25.7
2	44	25	38	20.3	11	6.3	6	3.2
3	-	-	-	-	1	0.6	3	1.6
4	-	-	-	-	0	0	0	0
Total	176	100	187	100	176	100	187	100

Table 34 shows that only 25% of the boys and 20.3% of the girls could identify correctly the containers to be used in the experiment. More than half of the boys and girls could not. However more boys performed better than the girls.

6.9% of the boys and 4.8% of the girls scored two and above marks on planning. This percentage is very low, meaning that the skill of planning is very low among both boys and girls. No one scored the maximum score of 4 marks on planning.

Question 8: A farmer had two types of soils, acidic and alkali soils. They wanted to find out which of the two soils is the best for planting cabbages. Describe how he would go about this.

This question was only testing planning of investigations.

The expected responses and scoring for the above question is given on table 35.

Table 35: Expected Responses for Question 8.

Response	Planning
- Have equal patches of land i.e. acidic and alkali	1
- Both patches get equal amount of -sunlight	1
-Water	1
-Fertilisers	1
- Cabbages should be of the same variety	1
- Cabbages should be equally spaced	1
- Both patches should be dug over in the same day and plant	1
- After mature count or weight the cabbage from both plots to fit to know the best soils.	1
Total	8

Most learners mentioned only a few of the variables that needed to be kept constant This determined the total score for each learner as shown on table 37. However some responses given by the learners were incorrect as shown in table 36.

Table 36: Incorrect Sample Responses from Learners on Question 8.

Responses
He should take the two soils and dissolve them in water differently. Let the soil particles to settle, then decant off the liquids from the containers and add a universal indicator to find the pH which is near (close) to the pH suitable for cabbages growth
Or Visit an agricultural officer. Tests could be carried on the soil to find the percentage of alkalinity and acidity. If the levels are very high, can be reduced with appropriate with appropriate fertilisers

The responses given in table 36 indicate that learners are not able to plan for an investigation. Most learners cannot design an experiment. This is further shown by the performance on the item in table 37

Table 37: Performance by Gender on Question 8.

	Boys		Girls		Total	
Scores	NO.	%	NO.	%	No.	%
0	102	58.0	133	71.1	235	64.7
1	42	23.9	37	19.8	79	21.8
2	16	9.1	13	7.0	29	8.0
3	11	6.3	3	1.6	14	3.9
4	4	2.3	1	0.5	5	1.4
5	1	0.6	-	-	1	0.3
TOTAL	176	100	187	100	363	100

Table 37 indicates that none of the learners' in the study sample scored above 5 marks with only 0.3% (1 learner) of the learners scoring the highest 5 marks.

Those who scored more than 40% the total marks that i.e. 3.2 marks were only 2.9% of the boys and 0.5% of the girls 9 (i.e. 5 boys and 1 girl). More than half of the learners i.e. 64.7% did not score any mark in the question. Generally the performance of the boys on the item was better than that of the girls. This is more evident in the final score of the whole paper as shown in table 38.

Table 38: Overall Performance on Biology Scientific Creativity Test

Creativity score in	Boys		Girls		Total	
%	No.	%	No.	%	No.	%
0 – 10	4	2.3	16	8.6	20	5.5
11 –20	33	18.7	58	31.0	91	25.1
21 – 30	55	31.3	76	40.6	131	36.1
31 – 40	51	29.0	26	13.9	77	21.2
41 – 50	26	14.7	10	5.4	36	9.9
51- 60	4	2.3	1	0.5	5	1.4
61 – 70	3	1.7	-	-	3	0.8
Total	176	100	187	100	363	100

Table 38 indicates that boys' did perform better than the girls'. 18.7% of the boys' scored 41% and above as compared to only 5.9% of the girls.

4.2.3. Level of Scientific Creativity in Biology.

The learners' scores on the various aspects of scientific creativity and the overall score on the test were categorised into either high or low. The criterion for determining the level in a given aspect was set at 40%. Hence a student who scored at least 40% of the marks in a given skill was judged to have a high level in that aspect of scientific creativity.

Table 39 shows the percentage of students by gender that has both high and low levels of scientific creativity for each aspect of creativity tested.

Table 39: Students' Performance on various Aspects of Scientific Creativity by Gender.

Aspects of scientific creativity	Boys		Girls		Total	
	High %	Low %	High %	Low %	High %	Low %
1. Flexibility in reasoning	51.1	48.9	28.3	71.7	39.4	60.6
2. Recognition of relationship	53.4	46.6	29.9	70.1	41.3	58.7
3. Sensitivity to problems	34.7	65.3	18.2	81.8	26.2	73.8
4. Planning of investigations	3.4	96.6	1.1	98.9	2.2	97.8
5.Overall scientific Creativity	22.2	77.8	6.4	93.6	14.0	86.0

The results in table 39 show the percentage of students by gender who scored at least 40% and above of the marks on each aspect of scientific creativity. The results indicate that 51%

of the boys scored high in flexibility as compared to only 28% of the girls. This shows that boys were able to generate more correct categories of ideas than the girls were.

53.4% of the boys could recognise relationships among concepts tested compared to 29.9% of the girls. Hence for this particular sample more boys than girls could recognise relationships among variables.

On sensitivity more boys (34.7%) performed better than girls (18.2%). The performance of the boys on this skill is however lower than flexibility (51%) and recognition of relationships (53.4).

Planning is the poorest performed of all the aspect with boys still performing better (3.4%) than the girls (1.1%).

The general level of creativity is low with only 22.2% of the boys and 6.4% of the girls scoring above 40%. More boys scored above 40% than the girls. Only 51 students, i.e. 14%, in total out of 363 scored above 40%. This shows that generally the level of scientific creativity in biology is low among form three biology students.

The results also show that generally boys are better than girls on all aspects of scientific creativity and the general scientific creativity level are. Also both boys' and girls' performed better in recognition of relationship, followed by flexibility then sensitivity and lastly planning. This performance on each aspect of scientific creativity gave the hierarchical order as shown figure 3 below.

Planning
↑
Sensitivity
↑
Flexibility
↑
Recognition of relationship.

Figure 3. Hierarchical Order on Performance on Aspects of Scientific Creativity.

Planning is at the top of the hierarchical order, suggesting that it was the poorest performed while recognition of relationship was the best performed.

Further comparison of the performance on scientific creativity by students and the category of schools are given in table 40 below.

Table 40: Students Performance on Aspects of Scientific Creativity and Category of Schools.

	School category					
	Boys		Girls		Mixed	
	High %	Low %	High %	Low %	High %	Low %
Flexibility	55.2	44.8	29.1	70.9	39.4	60.6
Recognition of relationship	62.1	37.9	32.1	67.9	37.3	62.7
Sensitivity	42.5	57.5	20.9	79.1	31.1	78.9
Planning	3.4	96.6	1.5	98.5	3.1	97.9
Overall scientific creativity	29.9	70.1	8.2	91.8	9.9	90.1

Results from table 40 indicate that the boys' schools performed better in all the four aspects of scientific creativity. They were also the best in the overall score of the creativity paper. The mixed schools followed boys' schools while the girls' schools had fewer girls getting above the average score of 40%.

Discussion of Results

The results in table 39 show that more than half of the boys scored above 40% both for flexibility and recognition of relationships. The percentage of girls scoring more than 40% was low with only 28.3% and 29.9% respectively for flexibility and recognition respectively.

More boys than girls scored more than 40% on sensitivity and planning (table 39) but the number of boys scoring above 40% was lower than on flexibility and recognition of relationships. This seems to suggest that aspects of sensitivity and planning are harder than flexibility and recognition of relationships.

Performances on recognition of relationships and flexibility were found to be higher than on sensitivity and planning. This would be due to the fact that aspects of flexibility and recognition of relationships are more content dependent. Learners use the knowledge learnt in class to interpret their environment.

Sensitivity and planning were poorly performed. These two are not content dependent. The results in table 47 and48 show that teachers do not include learning activities that would enable learners to be sensitive to problems and plan for experimental set up. This could be the reason why learners performed poorly on these skills. Sensitivity and planning falls under design of investigations in the scientific definitions. A study done by Okere (1991) on high school students and first year physics undergraduate students on design of scientific experiments produce similar results of students lacking the skill. He attributed to students watching demonstrations or carrying out practical activities by following instructions without understanding what they are doing.

4.3. Learning Opportunities Provided by Form Three Biology Teachers' that Enhance Acquisition of Scientific Creativity.

Introduction

The main aim of observing biology lessons was to determine the nature and quality of teacher – learner interaction. Both the teachers' and the learners' activities were observed. These were used to assess the opportunities provided in the biology lessons that would enhance the acquisition of scientific creativity skills.

The biology observation schedule (BOS) described in chapter three (see page 38, section 3.5.3) was used to record the activities as they occurred. Eight lessons were observed in each of the three schools giving a total of 24 lessons. Out of the eight lessons in each school observed, one was a practical lesson. For each school all the lessons' activities were accumulated together to give the average percentages of the classroom activities. The frequency of each activity was expressed as a percentage of the total activities that occurred within the period of observation. The results are shown from tables' 41 through to tables 48. Letters A to C denote the school in which the observation was made. Activities I to XI denote the following;

I Recalling facts and principles.

II Applying facts and principles to problem solving.

III Reformulating general statements.

IV Criticizing experimental procedures.

V Identifying variables.

VI Describing planning for experimental set up.

VII Describing uses of experimental results.

VIII Describing sources of experimental errors.

IX Describing sequences of investigations.

X Generating hypothesis.

XI Observation.

Teacher activities were divided into three categories, namely,

1a Teacher asks questions or invites comments that are answered by:

1b Teacher makes statements.

1c Teacher directs learners to sources of information for the purpose of:

Learner activities were divided into the following two categories,

2d Learners seeks information or consult for the purpose of.

2e Learners refer to teachers for the purpose of.

4.3.1. Activities Observed in Percentages during both Theory and Practical Lessons in School A are Shown in Tables 41 and 42.

In school A, activities observed during the theory lessons are shown in table 41.

Table 41: Activities Observed during Biology Theory Lessons in Percentages for School A.

	Occurrence of activities in %							
	Teacher activity				Learner activity			
Activities	1a	1b	1c	Total	2d	2e	Total	Grand total
I	28	54	2	84	0	5	5	89
II	8	0	0	8	0	2	2	10
III	0	0	0	0	0	0	0	0
IV	0	0	0	0	0	0	0	0
V	0	0	0	0	0	0	0	0
VI	0	0	0	0	0	0	0	0
VII	0	0	0	0	0	0	0	0
VIII	0	0	0	0	0	0	0	0
IX	0	0	0	0	0	0	0	0
X	1	0	0	1	0	0	0	1
XI	0	0	0	0	0	0	0	0
TOTAL	37	54	2	93	0	7	7	100

The above results (table 41) indicate that 89% of the classroom activities are on facts and principles with only 10% requiring application of facts and principles to problem solving. Generation of hypothesis, which is an aspect of scientific creativity, took up 1% of the classroom activities. All other activities, i.e. criticising experimental procedures, identifying variables, describing planning for an experimental set up describing uses of experimental results, describing sources of experimental errors, describing sequences of investigations and observations did not take place at all. This suggests that the activities that would enhance the learners' acquisition of skills on scientific creativity did not take place except the generation of hypothesis that only took 1% of the classroom activities.

The frequency of learners' activities was very low. For example, learners' activities took 7% of the lessons while 93% was dominated by teachers' activities. Out of the 93%, 54% was on teacher's statement and 37% was on teachers' questions. This indicates that teachers talk dominated the lesson, and hence the learners were less active.

The only kind of activities the learners were involved in was only when referring to the teacher for the purpose of acquiring or confirming facts and principles and applying facts and principles to problem solving. This only took 5% and 2% respectively of all the classroom activities. Learners did not at all consult one another in school A.

In school A, a practical lesson was observed and the table 42 indicates the activities that took place during the lesson.

Table42: Activities Observed in Percentages during Biology Practical Lesson for School A.

	Occurrence of activities in %							
	Teacher activity				Learners activity			
Activities	1a	1b	1c	Total	2d	2e	Total	Grand total
I	4	7	0	11	0	2	2	13
II	26	5	0	31	0	0	0	31
III	0	0	0	0	0	0	0	0
IV	0	0	0	0	0	0	0	0
V	0	0	0	0	0	0	0	0
VI	0	0	0	0	0	0	0	0
VII	5	2	0	7	0	0	0	7
VIII	0	0	0	0	0	0	0	0
IX	7	0	0	7	0	0	0	7
X	0	2	0	2	0	0	0	2
XI	36	2	0	38	0	2	2	40
TOTAL	78	18	0	96	0	4	4	100

Table 42 indicates that 13% of the practical lesson activities involved facts and principles. 31% involved application of facts and principles to problem solving as compared to 89% and 10% respectively during the theory lesson. This shows that less activities during practical lessons involved facts and principles as compared to the theory lessons. More activities involved application during the practical lessons than the theory lesson.

Activities that would enhance the acquisition of scientific creativity skills that occurred during the lesson included; 7% describing uses of experimental results, 7% describing sequences of investigations, 2% generating hypothesis and 40% observation. Other activities i.e. describing sources of experimental errors, reformulating general statements, identifying variables and describing planning for an experimental set up did not take place. However more activities on scientific creativity skills took place during the practical lesson then during the theory lesson.

However, teacher activities were 96% compared to 4% of the learner's activities. This gives a ratio of 24:1. This indicates that the learners are not actively involved even during practical lessons.

4.3.2. Activities Observed during both Theory and Practical Lessons in School B.

Activities observed during both theory and practical lesson in school B is shown in table 43 and 44 respectively.

Table 43: Activities Observed in Percentages during Biology Theory Lesson in School B.

	Occurrence of activities in %							
	Teacher activity				Learner activity			
Activity	1a	1b	1c	Total	2d	2e	Total	Grand total
I	19	54	3	76	2	3	5	81
II	8	1	0	9	0	0	0	9
III	0	0	0	0	0	0	0	0
IV	0	0	0	0	0	0	0	0
V	0	0	0	0	0	0	0	0
VI	0	0	0	0	0	0	0	0
VII	0	0	0	0	0	0	0	0
VIII	0	0	0	0	0	0	0	0
IX	0	0	0	0	0	0	0	0
X	3	0	0	3	0	0	0	3
XI	6	0	1	7	0	0	0	7
Total	36	55	4	95	2	3	5	100

Table 43 shows that 81% of the classroom activities were geared towards facts and principles. This is almost what was observed in school A (table 41) where facts and principles took up 89% of the classroom activities. 9% of the classroom activities were on application of facts and principles, generation of hypothesis 3% and observation 7%. This is as compared to

10%, 1%, and 0% respectively in school A (table 41). All other activities i.e. activities iii – ix did not take place. These activities are the one's that would enhance acquisition of scientific creativity skills. Only observation and generation of hypothesis would enhance the skill took place.

Teachers' activities recorded 95% as compared to 5% of the learners' activities. This gave a ratio of 19:1. This indicates that the classroom activities are dominated by the teacher activities. Of these teachers activities 76% is on facts and principles, with 54% being statements of facts and principles. The teacher did not make any statement on any other aspect of scientific creativity skills. This indicates that even teachers' activities do not provide opportunities that would help learners acquire the skills on scientific creativity in school B.

The percentage of activities that occurred in school B during the biology practical lesson is shown in table 44.

Table 44: Activities Observed in Percentages during Biology Practical Lesson in School B.

	Occurrence of activities in %							
Activities	Teachers activities				Learner activities			Grand total
Activities	1a	1b	1c	Total	2d	2e	Total	
I	12	9	0	21	0	4	4	25
II	12	0	0	12	0	0	0	12
III	0	0	0	0	0	0	0	0
IV	0	0	0	0	0	0	0	0
V	2	0	0	2	0	0	0	2
VI	0	0	0	0	0	0	0	0
VII	0	0	0	0	0	0	0	0
VIII	2	3	0	5	0	0	0	5
IX	8	0	0	8	0	3	3	8
X	0	2	0	2	0	0	0	2
XI	34	3	0	37	2	4	6	43
Total	70	17	0	87	2	11	13	100

Table 44 indicates that 25% of the classroom activities are on facts and principles. Of this 12% involve the teacher asking questions that are answered by recalling facts and principles and 9% involve the teacher making statements of facts and principles. This is as compared to 54% and 19% respectively during the theory lesson. This indicates that during practical lessons, facts and principles take up less of the activities as compared to the theory lesson. Application of facts and principles took up 12% of the activities as compared to 9% during the theory lesson. This was the trend in school A.

Activities that involve acquisition of scientific creativity skills that occurred during the lesson included observation 43%, describing sequences of investigations 8%, identifying variables 2%, sources of experimental errors 5%, and generation of hypothesis 2%. Other activities recorded 0%, i.e. reformulating general statements, criticising experimental procedure planning for experimental set up and describing uses of experimental results. However even those that occurred were teacher dominated. Generally activities that enhance the acquisition of scientific creativity skill occurred during practical lesson as compared to the theory lessons.

Most of the lesson activities are still dominated by the teacher recording 87% as compared to the learners' activities that recorded 13%.

4.3.3.C Activities Observed in Percentages during both Biology Theory and Practical Lesson in School C are Shown in Table's 45 and46 respectively.

Table 45: Activities Observed in Percentages during Biology Theory Lesson in School C

	Occurrence of activities %.							
	Teacher activity				Learner activity			
Activities	1a	1b	1c	Total	2d	2e	Total	Grand total
I	38	39	0	77	0	3	3	80
II	11	1	0	12	0	1	1	13
III	0	0	0	0	0	0	0	0
IV	0	0	0	0	0	0	0	0
V	0	0	0	0	0	0	0	0
VI	0	1	0	1	0	0	0	1
VII	0	0	0	0	0	0	0	0
VIII	0	0	0	0	0	0	0	0
IX	0	0	0	0	0	0	0	0
X	1	3	0	4	0	0	0	4
XI	0	2	0	2	0	0	0	2
TOTAL	50	46	0	96	0	4	4	100

Table 45 indicates that 80% of the lesson activities involve facts and principles. 13% involve application of facts and principles. The activities that would enhance acquisition of scientific creativity skills that occurred are generation of hypothesis 4%, observation 2% and describing planning for an experimental set up 1%. All these were teachers' activities. Learners' activities were 0%. Other activities that would enhance acquisition of scientific creativity skills i.e. reformulating general statements, criticising experimental procedures identifying variables, describing uses of experimental results and describing sources of experimental errors and describing sequences of investigations did not take place at all.

Teacher activities dominated the lesson recording 96% as compared to 4% of the learners activities this gives a ratio of 24:1 indicating that learners were passive.

During the practical lesson the activities that occurred are shown in table 46.

Table 46: Activities in Percentages during Biology Practical Lesson in School C.

	Occurrence of activities in %							
	Teacher activity				Learner activity			
Activities	1a	1b	1c	Total	2d	2e	Total	Grand total
I	4	7	0	11	0	3	3	14
II	1	1	0	2	1	0	1	3
III	0	0	0	0	0	0	0	0
IV	0	0	0	0	0	0	0	0
V	0	0	0	0	0	0	0	0
VI	0	0	0	0	0	0	0	0
VII	2	3	0	5	0	0	0	5
VIII	0	6	0	6	0	1	1	7
IX	12	0	0	12	2	8	10	22
X	0	24	0	24	0	0	0	24
XI	15	9	0	24	0	1	1	25
Total	34	50	0	84	3	13	16	100

Table 46 indicates that 14% of the activities dealt with facts and principles as compared to 80% during the theory lesson. Of this 14%, 7% were statements of facts and principles by the teacher, 4% on teacher's questions answered by recalling facts and principles. Only 3% was on learner's activities. This indicates that facts and principles occur less frequently during the practical lesson as compared to the theory lesson. This was also the case in schools A and B.

Application of facts and principles took up 3% of the lesson activities as compared to 13% during the theory lesson. This shows that application of facts and principles is more prevalent during the theory lesson than during the practical lesson. This was also the trend in schools A and B.

Activities that would enhance acquisition of scientific creativity that occurred during the lesson included describing uses of experimental results 5%, describing sources of experimental errors 7%, describing sequences of investigations 22%, generating hypothesis 24% and observation 25%. Other activities recorded 0%. This indicates that most activities that enhance the acquisition of scientific creativity took place during the practical lessons.

Teachers' activities recorded 84% as compared to 16% of learners' activities. This shows that even during practical lessons, teachers' activities dominated the classroom activities, just like the theory lesson.

A summary of the activities in % in the three schools is shown in table's 47 and 48.

Table 47: Summary of Activities in Percentages in the Three Schools During the Theory Lessons.

	Occurrence of activities in %							
	Teacher activity				Learner activity			
Activity	1a	1b	1c	Total	2d	2e	Total	Grand total
I	28.3	49	1.7	79	0.7	3.7	4.4	83.4
II	9	0.7	0	9.7	0	1	1	10.7
III	0	0	0	0	0	0	0	0
IV	0	0	0	0	0	0	0	0
V	0	0	0	0	0	0	0	0
VI	0	0.3	0	0.3	0	0	0	0.3
VII	0	0	0	0	0	0	0	0
VIII	0	0	0	0	0	0	0	0
IX	0	0	0	0	0	0	0	0
X	1.7	1	0	2.7	0	0	0	2.7
XI	2	0.7	0.3	3	0	0	0	3
TOTAL	41	51.7	2	94.7	0.7	4.7	5.4	100

Table 48: Summary of Activities in Percentages in the Three Schools during the Practical Lessons.

	Occurrence of activities in %							
	Teacher activities				Learner activities			
Activities	1a	1b	1c	Total	2d	2e	Total	Grand total
I	6.7	7.7	0	14.4	0	3	3	17.4
II	13	2	0	15	0.3	0	0.3	15.3
III	0	0	0	0	0	0	0	0
IV	0	0	0	0	0	0	0	0
V	0.7	0	0	0.7	0	0	0	0.7
VI	0	0	0	0	0	0	0	0
VII	2.3	1.7	0	4	0	0	0	4
VIII	0.7	3	0	3.7	0	0.3	0.3	4
IX	9	0	0	9	0	3.7	4.4	13.4
X	0	9.3	0	9.3	0.7	0	0	9.3
XI	28.3	4.7	0	33	0	2.3	3	36
Total	60.7	28.4	0	89.1	1.7	9.3	11	100

The above tables 47and 48 indicate that overall 83.4% of the theory lesson activities dealt with facts and principles as compared to 17.4% during the practical lessons. This indicates that facts and principles occur more during theory lessons than during the practical lesson. This was also the trend observed in the individual schools.

During the theory lessons 10.7% of the activities dealt with application of facts and principles as compared to 15.3% during the practical lessons. This shows that not much difference occurred during both practical and theory lessons on application although more occurred during the practical lessons.

More activities that enhanced acquisition of scientific creativity skills occurred during the practical lessons. These included identifying variables 0.7%, describing uses of experimental results 4%, and describing sources of experimental errors 4%, describing sequences of investigations 13.4%, generating hypothesis 9.3% and observation 36% compared to 0%, 0%, 0%, 0%, 2.7% and 3% respectively during the theory lessons. This indicates that most of the activities that enhance acquisition of scientific creativity occur more during practical lessons than during theory lessons. This was also observed in each of the individual schools. Other activities that enhance acquisition of scientific creativity, i.e., reformulating general statements criticising experimental procedures did not at all occur during both the theory and practical lessons. Describing planning for experimental set only occurred during the theory lessons recording 0.3%, which was mainly teacher statement made only in school C. Other schools did not have the activity.

In both theory and practical lessons, the teacher activities dominated during the lessons. During the theory lessons 94.7% of the activities were teachers and 5.4%

were learners as compared to 89.1%and 11% respectively during the practical lesson. However learners were more involved during the practical lessons than during the theory lessons.

The activities on teacher referring learners to other sources of information did not take place during the practical lessons, recording only 2% during the theory lessons. This indicates that teachers do not encourage learners to access other sources of information.

Discussion of Results.

The results in table 41, 43 and45 indicate that most of the classroom activities were geared towards facts and principles, taking up 89% in school A, 81% in school B and 80% in school C. Teacher activities dominated the classroom activities in all schools, school A, 93%, school B, 95% and school C, 96 % (table 41, 43, and45). From table's 47 and 48, it is clear that teacher's activities dominated both the theory and practical lessons. They take up more than half of the lessons, with the learner's activities taking up less than 10% of the lessons activities. This does not agree with the constructivitists models of learning that emphasizes learner's active participation during lessons. Jennings (1980) argues that the teaching of science should provide learners with opportunities that develop an openneness of mind that is receptive, though critically been provoked by the unexpected result. This will therefore make them seek alternative explanations and construct further tests. He goes further to argue that science also provides an opportunity for the development of thinking skills including logical and deductive thinking as well as creative and hypothetical thinking. These cannot occur with the passive participation of the learners during the lessons. Keraro (2002) made the same observation in his study of the influence of culture and learning opportunities on acquisition of science concepts and skills by Kenyan primary schools. He found that learning opportunities provided during primary science lessons were inadequate for effective learning of science.

Activities on facts and principles dominated the theory lessons with 83.4% (table 47). Of 79% were teacher activities with only 4.4% learners activities. This shows that learners asking questions on facts and principles were low. This is also in agreement with the results of Keraros' (2002) findings. Anderson *et al* (1989) carried out a study on description of classroom teaching and learning conducted in 8 countries and found that questions asked by the teachers were mainly answered by recalling of facts and principles. Questions that would enhance learners to acquire scientific creativity skills were virtually absent except for generation of hypothesis and observation during the theory lessons. But more activities occur during the practical lesson.

Generally activities that would enhance acquisition of scientific creativity were very rare during the theory lessons. More occurred during the practical lessons in both cases. Some of the activities were virtually absent. These included reformulating of general statements criticising of experimental procedures and describing planning for experimental set up. This indeed explains why items on the Biology scientific creativity test that tested on planning for experimental set up and reformulating of general statements were the poorest performed (table29). This shows that teachers do not provide learning opportunities to help learners develop skills of planning for experimental set up as well as criticising experimental procedures and reformulating general statements. Even the activities provided that enhance the acquisition of scientific creativity are few with more of rote learning taking place. This explains why the general level of scientific creativity is low among biology students (table38).

Teachers as noted before, do not provide enough learning opportunities that would enhance the acquisition of scientific creativity. Jennings (1980) talks of science teaching being formal and didactic with emphasis on note taking. This leads to convergent thinking being encouraged with memorization of terms and definitions seen as a key to passing exams. He also argues that teachers are faced with a dilemma of the pressure of the timetable and examination focus. This leads the teacher's attention to the syllabus to be covered tempting teachers towards transmission of information supported by dictated notes. This leads learners not to have an understanding of both the content and processes of science that enable learners to develop scientific creativity skills.

The practical activities observed in the three schools involved learners following already laid down procedures. This contributes to learners performing poorly on design of scientific experiment items that matched onto sensitivity and planning. Okere (1991) also observed this.

From the foregoing discussion, it is evident that teachers' in the biology lessons observed do not provide adequate learning opportunities that would help learners to develop scientific creativity. Also the quality of teacher learner interaction in the biology lessons observed does not encourage active and meaningful learning to take place. The lessons were teacher dominated meaning that there was emphasis on transmission view of learning as opposed to construction of knowledge that would help learners to develop scientific creativity.

4.4 Tests of Hypotheses.

4.4.1 The Relationship between the Level of Scientific Creativity in Biology and Knowledge.

The biology achievement test was used to measure the learners' knowledge in biology while the biology scientific creativity test was used to measure the learners' level of scientific creativity in biology. The learners' raw scores on the biology scientific creativity test and Biology achievement test were expressed as percentages and correlated. The SPSS programme was used to compute the Person Product Moment Correlation Coefficient for the scores obtained from the two tests. The results are shown in table 49.

Table 49: Pearson Product Moment Correlation Coefficient for Learners' Scores on the Biology Scientific Creativity Test and Biology Achievement Test.

	Mean	Std deviation	Learners score on the BAT	Learners score on the BSCT
Learners score on the BAT	46.6418	13.2821	1.00	0.577**
Learners score on the BSCT	26.6281	11.5446	0.577**	1.00

** Correlation is significant at the 0.05 level

The above result (table 49) shows that the mean score on the biology scientific creativity test was 26.628 with a standard deviation of 11.545. The mean score on the biology achievement test was 46.642 with a standard deviation of 13.282. The Pearson correlation coefficient for the BSCT and the BAT score r= 0.577. This was identified as being significant at the 0.05 level. This means that there was a positive correlation between the two sets of scores and it was significant. This implies that a good mastery of the biology content is essential for effective development of scientific creativity skills in biology.

Further correlation of the four aspects of scientific creativity with both the total creativity score and achievement score gave the results as shown in table 50.

Table 50: The Pearson Product Moment Correlation Coefficients for Learners Scores on Flexibility, Recognition of Relationship, Sensitivity, Planning, and Biology Achievement Test and Overall Biology Scientific Creativity Test.

	Flexibility	Recognition of relationship	Sensitivity	Planning	%BAT score	% BSCT score
Flexibility						
Recognition of relationship	.727**					
Sensitivity	.231**	.350**				
Planning	.283**	.381**	.617**			
% BAT score	.466**	.4866**	.399**	.390**		
% BSCT score	.743**	.839**	.685**	.749**	.571**	

**Correlation was significant at 0.05level

The results given in table 50 above indicate that flexibility, recognition of relationship sensitivity, planning, biology scientific creativity test scores and biology achievement test scores are all positively correlated. However some correlations are significant but quite low. For example between sensitivity and flexibility, sensitivity and recognition of relationship, planning and flexibility, planning and recognition of relationship. The low correlation between each aspect mentioned may mean that they measure different aspects of scientific creativity. However correlation between recognition of relationship and flexibility, and between sensitivity and planning were significant and high. This gives an indication that perhaps they measure the same aspect of creativity. It is important to note that flexibility in this case was measured in recognition of relationship, while sensitivity was measured in planning only.

Discussion of the Results.

The findings in table 49 indicate that the correlation between the learners score on the biology scientific creativity test and the biology achievement test was positive and statistically significant. This suggests that a good mastery of the biology content is essential for effective learning of scientific creativity in biology. These findings agree with Okere's finding (1986) where he found that physics knowledge contribute to creativity in physics. Weiner (2000) also argues that that knowledge of what has been generally, functions as a prerequisite to creating anything that has not been. Dunbar (1999) supports this when he points out that knowledge is pre-requisite for creative production in science.

Each aspect of scientific creativity correlates highly with the overall biology scientific creativity test (table 50). This indicates that they measure the same construct. The correlation between biology achievement test with sensitivity and planning was lower than with flexibility and recognition of relationship. Sensitivity and planning measure design of investigations on the scientific definitions of creativity, while flexibility and recognition of relationship measure generation of hypothesis. The findings indicate that biology knowledge may be contributing to the performance in generation of hypothesis and not design of investigations. This suggests that knowledge in biology is not a sufficient condition for one to develop the skill for design of investigations. This seems to further suggest that even those that do not perform well in the biology achievement test can learn the skill of design of investigations. These findings are in agreement with Okeres (1988) where he found that A level knowledge was contributing to performance on generation of hypothesis and not design of investigations. He also found that planning had high correlation with Torrance's test of creativity and not with knowledge test. This seems to suggest that knowledge is not a requirement for one to be able to plan and that planning alone can be used to measure the level of creativity among learners.

The above findings agree with Okere's (1986) findings. However he found sensitivity to have a low correlation with planning unlike in this research where two were highly correlated.

4.4.2 The Relationship between the Level of Scientific Creativity and Gender.

The learner's raw scores on the biology scientific creativity test were expressed as percentages. The scores were then categorised as high or low with a criterion reference of 40%. Depending on the analysis of the responses given by learners' on the BSCT, it was decided that 40% was the average score. Those who scored 40% and above were categorised as highly creative while those who scored less than 40% were categorised as having low scientific creativity.

Chi-square for the categorised scores and gender was computed using SPSS package version 9. The results are shown in table 51.

Table 51: Learners Categorised by Level of Scientific Creativity and Gender.

	Gender		
	Boys	Girls	TOTAL
High	39	12	51
Low	137	175	312
TOTAL	176	187	363

The Chi-square value was 18.606 with one degree of freedom. The test of significance was at 0.05. The critical Chi-square value is 3.84. The calculated value is greater than the critical value, and hence significant at 0.05 level. The hypothesis was therefore rejected. This shows that scientific creativity in biology is gender dependent.

Looking at each aspect of scientific creativity the following tables 52 and 53 show the difference by gender.

Table 52: Number of Learners by Gender for Each Categorised Score on each Aspect of Scientific Creativity in Biology.

	Boys		Girls		Total	
Aspects of scientific creativity	High	Low	High	Low	High	Low
Flexibility	90	86	53	134	143	220
Recognition of relationship	94	82	56	131	150	213
Sensitivity	61	115	34	153	95	208
Planning	6	170	2	185	8	355

From table 52, more boys had a high level of scientific creativity in biology than girls' in proportion to the total. The chi-square value was computed to find out whether there was a statistically significant relationship between gender and level of scientific creativity in each aspect of scientific creativity. The results are in table 53.

Table 53: Chi-Square Value of the Relationship between each Aspect of Scientific Creativity and Gender.

Aspects of scientific creativity	Value	df	Sig
Flexibility	19.731	1	.000*
Recognition of relationship	20.585	1	.000*
Sensitivity	12.740	1	.000*
Planning	2.303	1	.164

Chi- square critical value=3.84 * Significant at 0.05 level

The above table 53 shows that the chi-square value of flexibility, recognition of relationships and sensitivity were all significant. This indicates that there was a significant relationship between all aspects of scientific creativity and gender with the exception of planning.

4.4.3 Differences in Performance in Biology Scientific Creativity Test by Gender.

In order to identify which group performed significantly better in BSCT than the other, raw scores on each aspect of scientific creativity was used to compute their means. The results are shown in table 54 and 55.

Table 54: The Means and Standard Deviation by Gender on All Aspects of Scientific Creativity and Overall Scientific Creativity Test.

Aspect of scientific creativity	Gender	Mean	Std deviation
Flexibility	Boys	4.3807	1.9176
	Girls	3.5455	1.7202
Recognition of relationship	Boys	5.9801	2.2762
	Girls	4.6791	2.1399
Sensitivity	Boys	2.7614	1.6106
	Girls	1.9599	1.4700
Planning	Boys	2.6506	2.3528
	Girls	1.7968	1.7075
Scientific creativity	Boys	30.4091	11.6306
	Girls	23.0695	10.2889

From the above table 54 it is evident that the mean for boys is higher than the mean for girls in flexibility, recognition of relationship, sensitivity, planning and overall scientific creativity test.

Further analysis was done using independent sample t-test, to find out if the mean differences between boys and girls were significant. The table 55 shows the t-test results.

Table 55: t-test Results for Mean Differences between Boys and Girls Scores for various Aspects of Scientific Creativity in Biology.

Aspects of scientific creativity	t-value	df	Sig(2-tailed)
Recognition of relationship	5.613	361	.000*
Flexibility	4.373	361	.000*
Sensitivity	4.956	361	.000*
Planning	3.974	361	.000*
Overall scientific creativity	6.377	361	.000*

* Significant at 0.05 level

The above table 55 shows that the mean difference between boys and girls in all aspects of scientific creativity in biology and the overall scientific creativity in biology was significant in favour of the boys.

4.4.4 The Relationship between Level of Scientific Creativity and Category of School.

The 363 learners in the study sample were drawn from three categories of schools, namely boys, girls and mixed schools. Each school category was represented by two schools except for mixed that was represented by four schools. The scores for each learner in each school were categorised as high or low using a criteria reference of 40%. The chi-square value for flexibility, recognition of relationship; sensitivity and planning and overall biology scientific creativity, was computed using SPSS package. The results are shown in table 56 and 57.

Table 56: Number and Percentages of Learners' Performance by School Category on all Aspects of Scientific Creativity.

		School category					
Aspects of scientific		Boys		Girls		Mixed	
creativity	Level	No.	%	No.	%	No.	%
a) Flexibility	High	48	55.2	39	29.1	56	39.4
	Low	39	44.8	95	70.9	86	60.6
b) Recognition of	High	54	62.1	43	32.1	53	37.3
relationship	Low	33	37.9	91	67.9	89	62.7
c) Sensitivity	High	37	42.5	28	20.9	30	21.1
	Low	50	57.5	106	79.1	112	78.9
d) Planning	High	3	3.4	2	1.5	3	2.1
	Low	84	96.6	132	98.5	139	97.9
E) Overall scientific	High	26	29.9	11	8.2	14	9.9
creativity	Low	61	70.1	123	91.8	128	90.1

The above table 56 indicate that the boys had the highest percentage of those that passed in all the five categories followed by the mixed school and lastly the girls. This indicates that boys are the most creative followed by the mixed school and lastly the girls.

The following table 57 shows the chi-square values of each of the aspects of scientific creativity.

Table 57: Chi-square Values for the Relationship between Boys and Girls Categorised Scores on All Aspects of Scientific Creativity.

Aspects of scientific creativity	Value	df	sig
Flexibility	15.014	2	.001*
Recognition of relationship	21.091	2	.000*
Sensitivity	15.848	2	.000*
Planning	.945	2	.623
Overall Scientific creativity	23.917	2	.000*

Chi-square critical value=5.99 *Significant at 0.05 level

The above table 57 shows that the chi-square value of flexibility, recognition of relationship, sensitivity, and overall scientific creativity were all significant at 0.05 level of significance. Planning chi- square value was not significant. This indicates that level of scientific creativity, flexibility, recognition of relationship and sensitivity were related o the school category. The results also indicate that planning was not related to school category.

4.4.5 Differences in performance in Biology Scientific Creativity Test by School Category.

The raw scores for flexibility, recognition of relationship, sensitivity, planning and scientific creativity were used to compare means of category of schools. Their means were compared using one-way ANOVA statistical techniques the results are shown in tables 58 and 59.

Table 58: Means Scores and Standard Deviations of Learners in Aspects of Scientific Creativity by Category of Schools.

Aspects of scientific creativity	Category of school	N	Mean	Std deviation
Recognition	Boys	87	6.4943	2.0339
	Girls	134	4.8134	2.1431
	Mixed	142	5.0528	2.3533
	Total	363	5.3099	2.2981
Flexibility	Boys	87	4.8161	1.8523
	Girls	134	3.6194	1.6579
	Mixed	142	3.7324	1.9015
	Total	363	3.9504	1.8635
Sensitivity	Boys	87	2.9425	1.6720
	Girls	134	2.0858	1.5420
	Mixed	142	2.2324	1.4955
	Total	363	2.3485	1.5891
Planning	Boys	87	2.9943	2.4142
	Girls	134	1.9328	1.7694
	Mixed	142	1.9930	2.0438
	Total	363	2.2107	2.0873
Overall Scientific creativity	Boys	87	33.3218	11.1319
	Girls	134	23.9552	10.3516
	Mixed	142	25.0493	11.3390
	Total	363	26.6281	11.5446

From the table above 58 the mean score for the boys' is the highest in all the items, followed by the mixed school, while the girls' school is the lowest.

One-way ANOVA was computed to find out whether the mean differences between all aspects of scientific creativity are statistically different. The results are as shown in the table below 59.

Table 59: ANOVA results of the School Category Mean Scores of on Aspects of Scientific Creativity.

Aspects of scientific creativity		Sum of squares	df	Mean square	F	Sig
Flexibility	SSb	86.63	2	43.32	13.322	.000*
	SSw	1170.48	360	3.25		
Recognition of relationship	SSb	164.45	2	82.22	16.939	.000*
	SSw	1747.44	360	4.85		
Sensitivity	SSb	41.86	2	20.93	8.638	.000*
	SSw	872.31	360	2.42		
Planning	SSb	70.49	2	35.25	8.422	.000*
	SSw	1506.64	360	4.19		
Overall Scientific creativity	SSb	5209.42	2	2604.71	21.788	.000*
	SSw	43037.36	360	119.55		

*Significant at 0.05

SSb-sums of square between and SSw-sums of square within

From the table above, the F-values indicate that the three categories of schools differed significantly from one another in all cases i.e. in flexibility, recognition of relationship, sensitivity, planning and overall biology scientific creativity. However the results do not indicate the group means that differed significantly from one another. Post Hoc pair wise comparison; using Bonferoni and Turkey were used. The results are shown in table 60.

Table 60: The Post Hoc Pair wise ANOVA Result for Mean Scores by Schools of different Categories on all Aspects of Scientific Creativity.

Aspects of scientific creativity	School category	Boys	Girls	Mixed
Flexibility	Boys Schools	-	1.1967*	1.0837*
	Girls Schools	-1.1967*	-	-.1130
	Mixed Schools	-1.0837*	.1130	-
Recognition relationship	Boys Schools		1.6808*	1.4414*
	Girls Schools	-1.6808*	-	-.2394
	Mixed Schools	-1.4414*	.2394	-
Sensitivity	Boys Schools		.8567*	.7101*
	Girls Schools	-.8567*	-	-.1466
	Mixed Schools	-.7101*	.1466	-
Planning	Boys Schools		1.0614*	1.0013*
	Girls Schools	-1.0614*	-	-6.0122E-02
	Mixed Schools	-1.0013*	6.012E-02	-
Scientific creativity	Boys Schools		9.3666*	8.2725*
	Girls Schools	-9.3666*	-	-1.0941
	Mixed Schools	- 8.2725*	1.0941	-

* Significant at 0.05 level

The above results show the difference in-group means and the group means where a significant difference was identified. Both the Bonferoni and turkey tests produced the same result. The group means between which a significant difference was obtained are boys and girls group means, boys and mixed schools group means. The results indicate that boys did better in all the skills of scientific creativity. Group means between girls and mixed schools were not significant at 0.05 level.

4.4.6 School Difference in Biology Scientific Creativity Test and Biology Achievement Test

In this section, a search for the relationship between rank order of schools using the biology achievement test and mean score performance in all aspect of scientific creativity was conducted. The results are presented in table 61.

Table 61:Mean scores for each Individual School on all Aspects of Scientific Creativity and Biology Achievement Test (BAT).

	Schools							
	A	B	C	D	E	F	G	H
BAT	54.7	53.9	50.1	48.6	45.1	44.4	39.3	31.6
Recognition of relationship	6.66	6.30	4.25	6.71	5.65	5.23	3.80	3.50
Flexibility	4.66	4.96	3.65	4.66	4.15	3.60	3.05	2.62
Sensitivity	2.79	2.72	1.83	3.20	2.39	2.28	1.71	1.95
Planning	3.45	2.78	1.91	3.23	1.90	1.95	1.12	1.29
BSCT	33.8	32.4	22.4	34.3	27.2	25.1	18.6	18.1

The table above 61 indicates that the school rank order of schools using the knowledge test is not the rank order of all aspects of scientific creativity. This is evidence that the two tests require different skills and hence different learning experiences.

The statistical significance of the differences between the mean scores of the schools was investigated using one-way ANOVA. The results are shown in table 62.

Table 62: ANOVA Results of the Individual School Mean Scores of all Aspects of Scientific Creativity and Biology Achievement Test.

Aspects of scientific creativity		Sums of squares	df	Mean square	F value	Sig
Recognition of relationship	SSb	428.12	7	61.16	14.633	.000*
	SSw	1483.77	355	4.18		
Flexibility	SSb	173.94	7	24.85	8.144	.000*
	SSw	1083.17	355	3.05		
Sensitivity	SSb	79.31	7	11.33	4.818	.000*
	SSw	834.85	355	2.35		
Planning	SSb	198.21	7	28.32	7.290	.000*
	SSw	1378.92	355	3.88		
Overall scientific creativity	SSb	11408.82	7	1629.83	15.706	.000*
	SSw	36837.97	355	103.77		
Achievement test	SSb	12610.37	7	1801.48	12.593	.000*
	SSw	48781.86	355	143.06		

*Significant at 0.05level.

Note:

SSb-sums of square between and SSw-sums of square within.

Table 62 shows that the mean score differences between schools in all aspects of scientific creativity and the achievement test were all significant. To identify the schools that differed significantly Post Hoc pair wise comparison was used. Bonferoni and turkey produced the same results. The results are show in the tables 63.

Table 63: The Post Hoc Pair wise ANOVA results.

(i) Flexibility

	A	B	C	D	E	F	G	H
A		-.299	1.01	-6.42E-04	.512	1.06	1.61*	2.04*
B	.297		1.31*	.298	.810	1.36*	1.91*	2.34*
C	-1.01	-1.31*		-1.01	-.497	5.12E-02	.602	1.03
D	6.42E-04	- .298	1.01		.512	1.06	1.61*	2.04*
E	-.512	-.81	.497	-.512		.549	1.1	1.53*
F	-1.06	-1.36*	-5.12E-02	-1.06	-.549		.55	.978
G	-1.61*	-1.91*	-.602	-1.61*	-1.1	-.55		.429
H	-2.04*	-2.34*	-1.03	-2.04*	-1.53*	-.978	-.429	

(ii) Recognition of Relationship.

	A	B	C	D	E	F	G	H
A		.354	2.40*	-4.9E-02	1.01	1.43*	2.86*	3.16*
B	-.354		2.05*	-.403	.658	1.08	2.51*	2.80*
C	-2.4*	-2.05*		-2.45*	-1.39*	-.97	.457	.754
D	4.9E-02	.403	2.45*		1.06	1.48*	2.91*	3.21*
E	-1.01	-.658	1.39*	-1.06		.419	1.85*	2.15*
F	-1.43*	-1.08	.973	-1.48*	-.419		1.43*	1.73*
G	-2.86*	-2.51*	-.457	-2.91*	-1.85*	-1.43*		.298
H	-3.16*	-2.80*	-.754	-3.21*	-2.15*	-1.73*	-.298	

(ii) Sensitivity.

	A	B	C	D	E	F	G	H
A		7.2E-02	.965	-.406	.399	.51	1.08	.837
B	-7.2E-02		.893	-.478	.327	.438	1.00	.765
C	-.965	-.893		-1.37*	-.566	-.455	.11	-.128
D	.406	.478	1.37*		.805	.916	1.48*	1.24
E	-.399	-.327	.566	-.805		.111	.676	.438
F	-.51	-.438	.455	-.916	-.111		.565	.327
G	-1.08	-1.00	-.11	-1.48*	-.676	-.565		-.238
H	-.837	-.765	.128	-1.24	-.438	-.327	.238	

(iii) Planning.

	A	B	C	D	E	F	G	H
A		.665	1.54*	.216	1.55*	1.5*	2.33*	2.16*
B	-.665		.870	-.449	.880	.835	1.66*	1.497
C	-1.54*	-.870		-1.32*	9.8E-03	-3.6E-02	.793	.627
D	-.216	.449	1.32*		1.33	1.28*	2.11*	1.95*
E	-1.55*	-.88	-9.8E-03	-1.33		-4.6E-02	.783	.617
F	-1.5*	-.835	3.6E-02	-1.28*	4.6E-02		.829	.662
G	-2.33*	-1.66*	-.793	-2.11*	-.783	-.829		-.167
H	-2.16*	-1.5	-.627	-1.95*	-.617	-.662	.167	

(V) Overall Scientific Creativity

	A	B	C	D	E	F	G	H
A		1.35	11.4*	-.528	6.62	8.67*	15.2*	15.7*
B	-1.35		10.0*	-1.88	5.26	7.32*	13.9*	14.3*
C	-11.4*	-10.0*		-11.9*	-4.78	-2.73	3.83	4.29
D	.528	1.88	11.9*		7.15*	9.2*	15.8*	16.2*
E	-6.62	-5.26	4.78	-7.15*		2.05	8.62*	9.08*
F	-8.67*	-7.32*	2.73	-9.20*	-2.05		6.57*	7.02
G	-15.2*	-13.9*	-3.84	-15.8*	-8.62*	-6.57*		.452
H	-15.7*	-14.3*	-4.29	-16.2*	-9.08*	-7.02	-.452	

(vi) Biology achievement test.

	A	B	C	D	E	F	G	H
A		.787	4.57	6.15	9.64*	10.3*	15.4*	23.2*
B	-.787		3.79	5.36	8.85*	9.55*	14.6*	22.4*
C	-4.57	-3.79		1.58	5.06	5.76	10.8*	18.6*
D	-6.15	-5.36	-1.58		3.49	4.18	9.23*	17.0*
E	-9.64*	-8.85*	-5.06	-3.49		.697	5.74	13.5*
F	-10.3*	-9.55*	-5.76	-4.18	-.697		5.04	12.8*
G	-15.4*	-14.6*	-10.8*	-9.23*	-5.74	-5.04		7.78
H	-23.2*	-22.4*	-18.6*	-17.0*	-13.5*	-12.8*	-7.78	

* Significant at 0.05 level

From the above tables (63i-vi), it is evident that the mean scores of school A, B, C and D differed significantly from schools E, F, G and H in the biology achievement test. However this was not the trend for all the other aspects of scientific creativity. This indicates that scientific creativity test measures different skills from the achievement test.

Discussion of Results.

The chi-square results revealed that the level of scientific creativity is gender dependent (table 51). The aspects of scientific creativity i.e., flexibility, recognition of relationship and sensitivity are all gender dependent (table 53). However the chi-square value of planning was not significant. This indicates that planning is not gender dependent as per this study. The same trend was observed on the category of schools. The chi-square results showed that planning was not dependent on category of schools. All other aspects of scientific creativity were dependent on category of schools, (table 57). These findings indicate that girls' who are mainly considered to perform poorer in science as compared to the boys can effectively acquire the skill of planning if provided with learning opportunities to encourage its development. Thus both boys' and girls' can succeed in investigative activities, which are very important for technological development. These findings also indicate that planning can be taught to any group of learners whether mixed or single sex schools. All these findings are in agreement with Collete and Chiappetta (1994) who argue that all students can learn science and they can learn best by doing. This could be because creativity is not an inherent trait but one that can be developed and cultivated, (Loehle, 1990).

The mean scores on all aspects of scientific creativity (table 54), indicated that boys performed better in all aspects i.e. flexibility, recognition of relationship, sensitivity, and planning and overall scientific creativity. The ANOVA results in table 55 indicated that the mean differences between the boys and girls were significant. The difference could be related to knowledge level in biology. Boys had a higher mean score in both the creativity scores and achievement scores as shown in the table below 64

Table 64: Comparison of Means Scores of both BSCT and BAT by Gender.

	Gender	N	Mean	Std deviation
BSCT	Boys	176	30.4091	11.6306
	Girls	187	23.0695	10.2889
BAT	Boys	168	48.8929	13.4044
	Girls	181	44.5525	12.8549

BAT was found to correlate positively with BSCT. Therefore the low level of scientific creativity in girls than boys can be linked also to the knowledge level of girls as compared to the boys. Other researches done in gender difference in science achievement agree with boys doing better than the girls. For example Otieno 1991 did a study on competence of junior secondary school pupils in some science process skills and found that boys performed much better as compared to the girls. Most science process skills are related to scientific creativity skills as seen in fig 2.1 page 20. This is as stated by steinkamp and Maehr (1983,1984) that quantitative review of gender differences in school science achievement all reveals significant gender differences in science achievement.

One of the reasons given on the difference in level of scientific creativity and creativity generally between boy and girls is the association of some traits with masculinity and femininity, namely, cultural block (Adams 2001). However Weiner (2000) and Adams (2001) indicate that, emotion openness and sensitivity are traits often associated by psychologist as indicative of creativity and yet they are ones own culture traditionally stereotypes as 'female'. However more studies need to be done on the kind of blocks hindering females from been as creative as males.

Differences emerged on the performances between boys, girls and mixed schools. The boys' schools performed best followed by the mixed schools, then the girl's schools in the scientific creativity test. This could be attributed to differences in the learning environments that could be found in the different category of schools. Also, after ranking each school in order of performance on the achievement test, it emerged that ranking on other aspects of scientific creativity was different. This indicates that schools that perform well in the knowledge test do not necessarily do well in the scientific creativity aspects. This is in agreement with Okere's findings in which he found that weak schools differed significantly from good schools in the A level test and not in the design of investigations.

CHAPTER FIVE

SUMMARY, CONCLUSIONS, IMPLICATION AND RECOMMENDATIONS.

5.1 Introduction.

This study aimed at investigating the effects of gender, knowledge and learning opportunities on scientific creativity among form three biology students in Nakuru district. The instruments used in this study were the biology scientific creativity test, the biology achievement test and biology observation schedule. This chapter presents a summary of the major findings, the conclusions made and the implications of the findings. Recommendations and suggestions for further research are also discussed.

5.2 Summary of the Major Findings.

On the basis of the data analysis presented in chapter four the following are the major findings arising from this study:

1. The level of scientific creativity in biology among form three learners in the study sample was generally low.
2. Aspects of flexibility and recognition of relationships were better performed than on sensitivity and planning.
3. Some of the responses given by the learners on items on the BSCT show that learners' responses do not agree with scientific explanations of the particular items.
4. The relationships between learners' performance on the Biology achievement test and the Biology scientific creativity test were statistically significant. The correlation was positive and significant ($r = 0.577$), at 0.01 level of significance

5. The relationship between the level of Biology scientific creativity and gender was positive and significant. The chi-square value was 18.606. This indicates that the level of scientific creativity in Biology is gender dependent. The chi-square results of flexibility, recognition of relationship, and sensitivity indicated that they are all gender dependent. Planning was not gender dependent.
6. The chi-square results of all aspects of scientific creativity with the category of schools all indicated that all aspects of scientific creativity are dependent on category of schools with the exception of planning
7. The t-test results indicated a significant difference in performance of the biology scientific creativity test, flexibility, recognition of relationship, sensitivity and planning between boys and girls in favour of boys'.
8. Flexibility, recognition of relationship, sensitivity and planning are all positively correlated between each and with the overall biology scientific creativity. However the correlation between flexibility and recognition of relationship and between sensitivity and planning was high. Correlation between flexibility and sensitivity, flexibility and planning, recognition of relationship and sensitivity and recognition of relationship and planning was low. This indicates that flexibility and recognition of relationship measure different aspects of scientific creativity from sensitivity and planning. In this study flexibility was tested on recognition of relationship, while sensitivity was tested on planning.
9. The learning opportunities provided during biology lessons were inadequate for enhancing learners to acquire scientific creativity skills.
10. Biology scientific creativity test does not place the schools, on the rank order predicted by the biology achievement test. The differences could be attributed to the different learning experiences needed by the two tests.

11. There is an indication that generation of hypothesis correlates highly with the biology achievement test than with the design of investigations. This indicates that design of investigations measures a different trait that is not knowledge dependent and hence can be used to measure creativity in biology.

5.3 Conclusions.

The major focus of this study was to investigate the effects of gender, knowledge and learning opportunities on scientific creativity among form three biology students. On the whole, the findings of the study indicate that the level of scientific creativity in biology is generally low. This is probably due to the fact that teachers do not provide adequate learning opportunities that would enhance acquisition of scientific creativity. Most of the classroom activities were teacher dominated with a majority dealing with facts and principles. Some of the activities that would help learners acquire the scientific creativity did not take place at all. Learning opportunities on planning and sensitivity do not take place at all during the biology lessons and this explains why the items testing these two aspects were the poorest performed.

The relationship between level of scientific creativity and gender was found to be positive and statistically significant. Various aspects of scientific creativity were also found to be gender dependent except for planning. This indicates that even girls that are considered perform poorer in science can develop this skill, if provided with the appropriate learning opportunities. Thus both boys' and girls' can succeed in investigative activities, which are very important for technological development.

Boys were found to be more creative than girls. The t-test results indicated a significant difference between boys and girls mean scores on all aspects of scientific creativity and the overall creativity scores. Performance on all aspects of scientific creativity and overall scientific creativity was found to be dependent on category of schools. This was in favour of the boys' schools, followed by the mixed and then the girls' schools.

The Pearson Product Moment correlation coefficient between level of scientific creativity and knowledge in biology was also found to be positive and significant. This therefore, implies that a good mastery of the biology content is essential for scientific creativity in biology. However the Biology Scientific Creativity Test did not rank the schools in order as predicted by the Biology Achievement Test. This implies that scientific creativity test measures different skills from the achievement test. This also implies that knowledge in biology is not a sufficient condition for one to be creative.

The Pearson Product Moment correlation coefficient between biology achievement test with flexibility and recognition of relationship was higher than with sensitivity and planning. Sensitivity and planning are aspects of scientific creativity that measure design of investigations on the scientific definitions of creativity, while flexibility and recognition of relationship measure generation of hypotheses. This suggests that knowledge in biology is not a sufficient condition for one to develop the skill of design of investigations. This further suggests that even those that do not perform well in the biology achievement test can learn the skill of design of investigations.

5.4 Implication of the Findings and Recommendations.

The findings of this study have a number of implications. They suggest that the general level of scientific creativity in biology is low. This was found to be so because teachers were not providing adequate opportunities to enhance the learners to acquire the scientific creativity. Adams (2001) argues that teachers do not encourage the questioning attitude among learners, which is necessary to motivate conceptualisation. He goes further to explain that if questions are not encouraged, learners are not able to see needs and problems i.e. sensitivity, yet creativity allows self-actualisation. Amabile (1983) quotes Albert Einstein who said, "It is nothing short of a miracle that the modern methods of instruction have not yet entirely strangled the holy curiosity of inquiry. It is a very grave mistake to think that enjoyment of seeing and searching can be promoted by means of coercion and a sense of duty." This is supported by Weiner (2000) who explains that teachers tend to lead students step by step towards an established fixed realm called knowledge in which the teacher appears as the possessor of the object of knowledge. This results in exploration and creativity being minimised. This shows that teachers need to make use of more instructive approaches, encouraging questioning attitude in the learners so as to actively involve learners in the teaching learning process. This would ensure learners acquire scientific creativity skills. Also regular in-service courses and workshops would be necessary if this goal is to be achieved. More time may also need to be allocated to the science lessons in the school timetable. This would allow learners enough time to explore and be curious so as to be creative.

Amabile (1983) findings of research in educational institutions system of rewards and punishment found that, it hinders creativity. He explains that the acknowledgement of one "right answer" reduces room to imagine and be innovative. This explains why once through the process of education, most people lose the capacity of wondering of being surprised they feel they ought to know everything and hence that it is a sign of ignorance to be puzzled at or surprised by anything. This does, in long term, hinder the attainment of one main objective of education in Kenya and in turn the hopes of our country Kenya to be industrialised by the year 2020 (Republic of Kenya, 1992 & 1997). If this has to be achieved the KNEC should include questions that test scientific creativity in schools. Also K.I.E should include more activities in the school curriculum and in particular science syllabus that would enhance the acquisition of scientific creativity.

The findings of this study indicated that knowledge in biology is necessary for one to be creative in biology. Weiner (2000) argues that knowledge of what have been generally functions as a prerequisite to creating anything that has not been. This means that teachers should provide learning opportunities to encourage scientific creativity. The content of biology must also be taught hand in hand with scientific creativity but not to encourage rote learning.

Gender was found to have a relationship with the level of scientific creativity. Boys were found to be more creative than girls. However Weiner (2000) and Adams (2001) indicate that, emotion openness and sensitivity are traits often associated by psychologist as indicative of creativity and yet they are ones own culture traditionally stereotypes as 'female'. This indicates that if girls are encouraged and helped to eliminate cultural blocks that limit their opportunities for creative expression, perhaps they can produce greater creative works in sciences. This has already been observed and documented so that groups treated as 'marginal' by a society often produce highly creative individuals like the Jew (Weiner, 2000).

5.5 Suggestions for Further Research.

The findings of this study suggest that knowledge in biology does affect level of scientific creativity in biology. This is in agreement with a study carried out by Okere (1986). Learning opportunities provided during biology lessons were inadequate for enhancing development of scientific creativity skills among learners. This is in agreement with a study carried out by Keraro (2002). This study further suggests that gender does affect the level of scientific creativity. However, further research is required to corroborate these findings, and more especially in the following areas of concern.

1. Investigations with a large sample involving more schools from different regions of Kenya.
2. Studies aimed at finding out more obstacles to scientific creativity.
3. Studies aimed at evaluating effects of schools categories (mixed or single sex schools) on level of scientific creativity
4. Studies on national examinations and school syllabus and textbooks content analysis on scientific creativity.
5. Investigating influence of culture on scientific creativity
6. Investigating teachers understanding of scientific creativity.

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Appendix one

BIOLOGY ACHIEVEMENT TEST

FORM THREE

NAME: ....

SEX:........................

SCHOOL:....................................

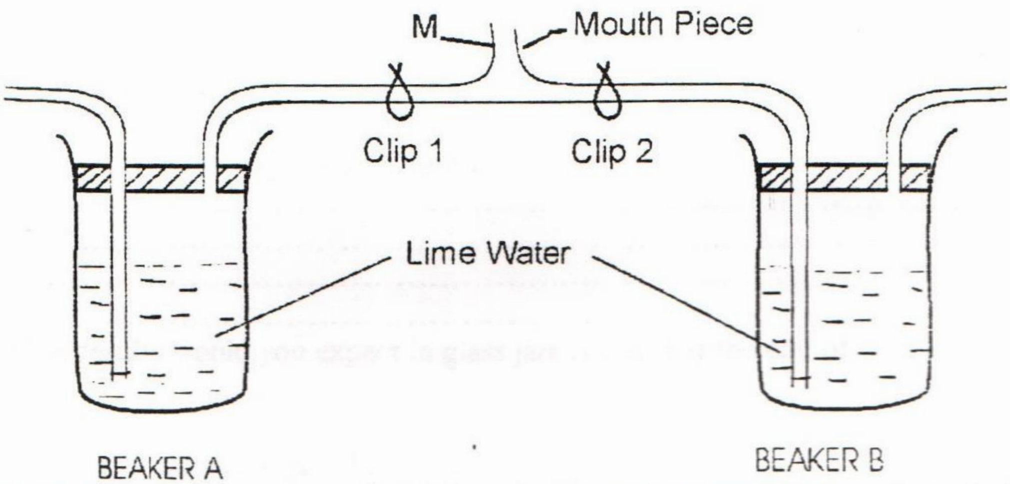
INSTRUCTIONS:

(a) Answer all the questions in the space provided.

(b) Take time to answer all the questions.

QUESTIONS

1) The diagram below represents the apparatus that can be used to investigate an aspect of gaseous exchange in man.



A person placed his mouth at tube M, breathed in and out several times through the tube.

(a) i. What results are expected after breathing in and out several times in the two beakers?

....

....

....

....

ii. Explain the expected results in a (i) above

....

....

....

....

....

....

iii. State the purpose of clips1 and 2 in this experimental set up above.

....

....

....

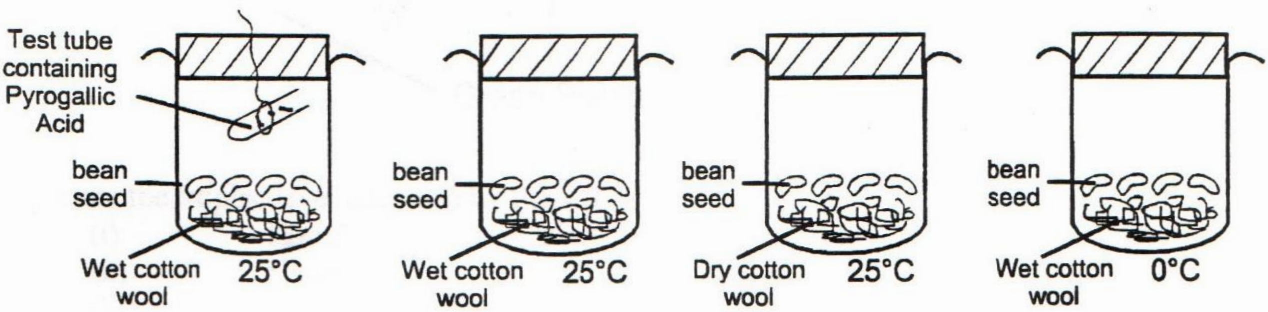
(b) State two advantages of breathing through the nose rather than through the mouth.

....

....

....

2. In an experiment, a group of students set up four glass jars as shown in the diagram below. Jars A, B and C were all maintained at 25°C for 7 days while jar D was maintained at O°C for the same period of time.



(a) (b) (c) (d)

(a) What was this set up supposed to investigate?

....

(b) What was the use of pyrogallic acid in the glass jar A?

....

(c) What was the use of glass jar C and D?

....

....

....

....

(d) What results would you expect in glass jars A and B at the end of the experiment?

....

.... (e)

State two artificial methods of breaking seed dormancy.

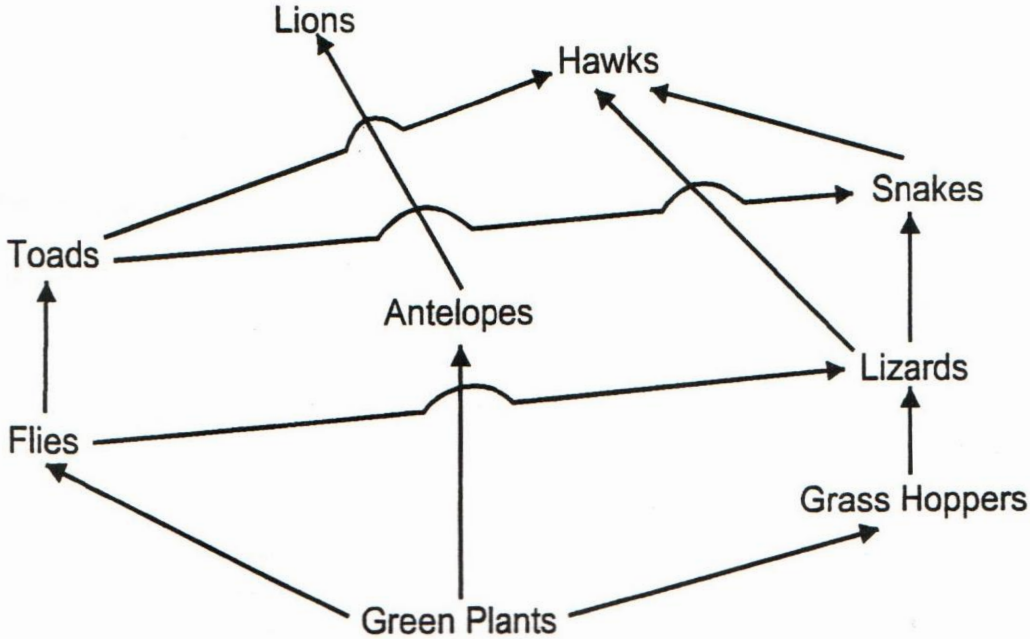
....

....

3. The diagram below represents a food web in a terrestrial ecosystem.

(a) Using the below food web, construct a food chain with five organisms.

....



(b) State the trophic level occupied by the following

(i) Lizards.................................

(ii) Hawks.................................

(iii) Antelopes.................................

(iv) Green plants.................................

(c) What would happen if leopards were introduced in the ecosystem?

....

....

....

....

4. In an experiment carried out in a tropical country, carbon dioxide concentration was measured around a plant in open air at two-hour intervals for a period of 24 hours. The results were as shown in the table below:

Time	Percentage of carbon-dioxide concentration ($X10^{-2}$)
3 a.m	3.40
5 a.m.	3.60
7 a.m	3.90
9 a.m	3.20
11 a.m	2.90
1 p.m	2.90
3 p.m	2.90
5 p.m	2.92
7 p.m	3.02
9 p.m	3.10
11 p.m	3.20
1 a.m	3.30
3 a.m.	3.40

(a) Using the data, plot a graph of carbon dioxide concentration against time on the grid provided.

(b) Calculate the rate of change (i.e. the gradient) in carbon dioxide concentration between 4 a.m. and 7 a.m.

....
....
....

(c) Why do you think the concentration of carbon dioxide changed between the following times?

(i) 7 a.m. to 11 a.m.

....
....
....
....

(ii) 12 noon and 4 p.m.

....
....
....
....
....

(d) The experiment was repeated on a different day and the results obtained were different.

(i)Name two environmental factors that were likely to have affected the results.

....
....

(ii) How would the factors you have named in (d) (i) above affect the results?

....
....
....
....
....
....

5. In an investigation, a student collected two plants A and B. Plant A had hairy leaves and few stomata, which were sunk into the epidermis. Leaves of plant B were broad and had many stomata on the upper surface only. In which habitat would you find?

(i) Plant A...

(ii) Plant B...

6. The equation below shows a chemical reaction that takes place in green plants under certain conditions

Carbon dioxide + water → Glucose + x.

(a) What is the name of substance x?

....

(b) Other than the reactants, state two conditions necessary for this reaction.

....

(c) Name the process represented by the given equation.

....

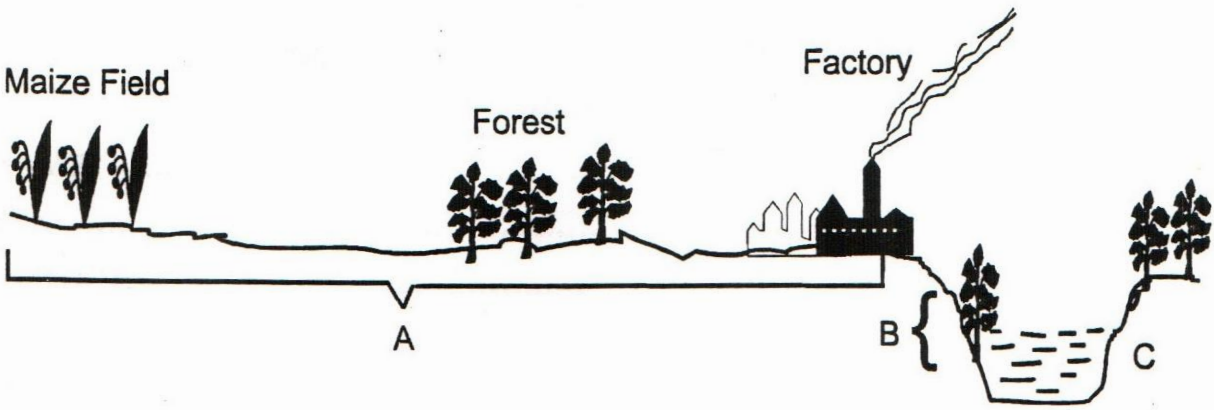
(d) Name the cells in which this process occurs.

....

(e) Name the organelle in which this process takes place.

....

7. The diagram below shows a cross section of a valley.



Study the diagram and answer the following questions.

(a) Name two animals and two plants that are likely to be found at region B.

(i)……………………………………………………………………………

(ii)……………………………………………………………………………

(b) State two adaptations that would be found in plants growing at region C.

(i)……………………………………………………………………………

(ii)……………………………………………………………………………

(c) What are the human activities in region A?

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

(d) How would the human activities identified in 7 (c) affect the life of organisms at regions B and C above.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

Appendix two

BIOLOGY SCIENTIFIC CREATIVITY TEST

FORM THREE:

NAME: ....

SEX: ....

SCHOOL: ....

INSTRUCTIONS:

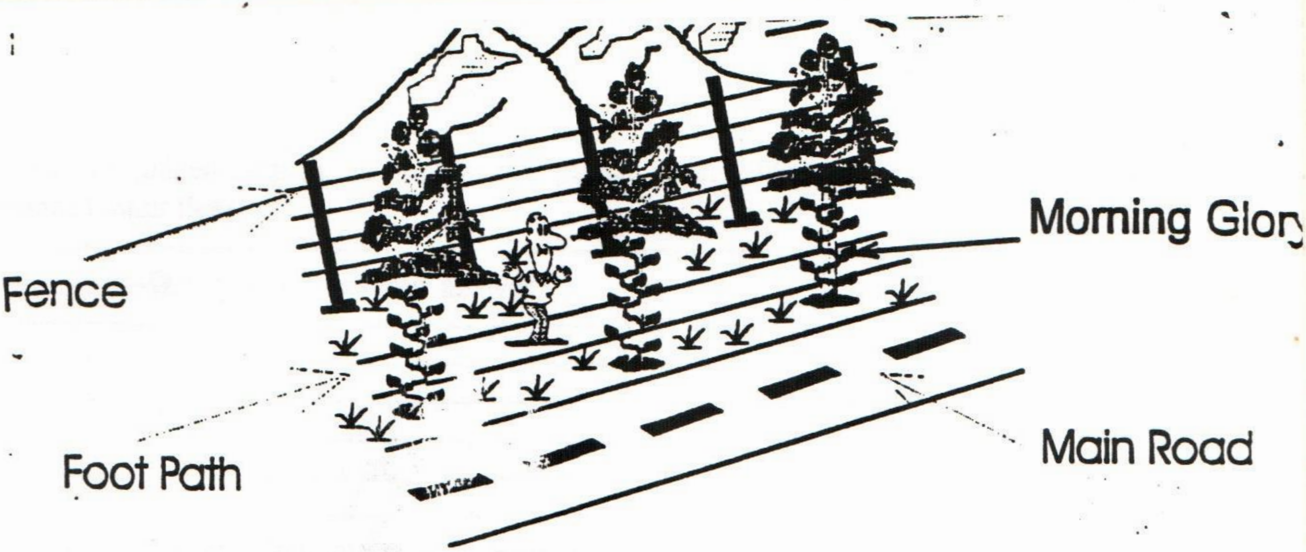
(a) Answer all the questions in the spaces provided.

(b) Take time to answer all the questions.

QUESTIONS

1.Grasshoppers attract their mates by using sound. Peacocks attract their mates using colour. Suggest four possible reasons why grasshoppers use sound rather than colour.

2.Walking along the footpath shown in the diagram below, Thomas noticed that there was a morning glory plant growing on the trees, but only around three-quarters of the trunks. None of the trees had the morning glory plant growing on the side nearest to the foot path.



Suggest at least four different reasons why the morning glory plant might grow only on some sides of the trees.

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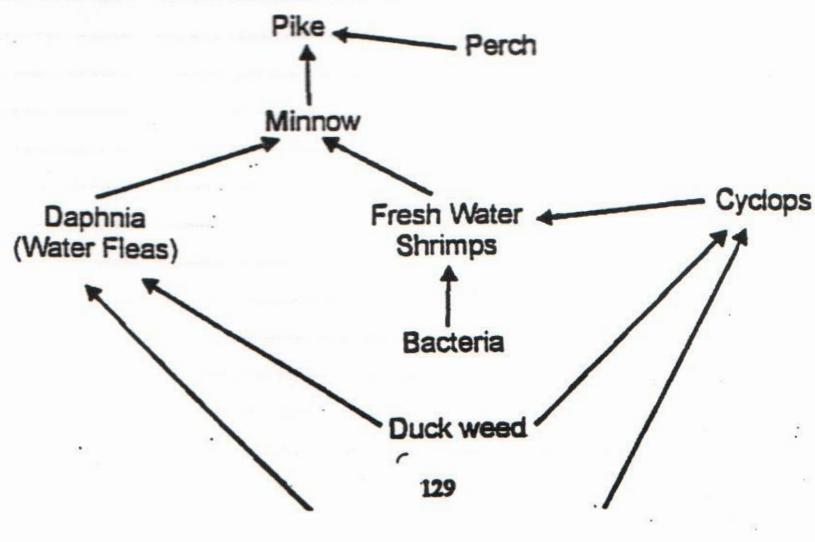
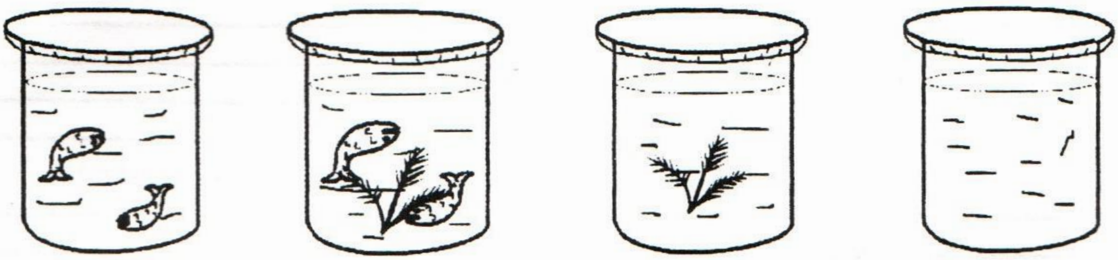
3.The diagram below shows the way some animals and plants living in a canal depend on each other.



If there is a sudden drop in the number of Cyclops, what is likely to happen to the numbers of Daphnia (water flea)?

----------------Give reasons for your answer.

4.Early one morning, four containers were set up as shown in the diagram. The tops were airtight. They were left in a well-lit place for eight hours. After these time it was suggested that the water in two of the containers would have about the same amount of oxygen and also about the same amounts of carbon dioxide as each other.



(a) Do you agree or disagree with the suggestions.

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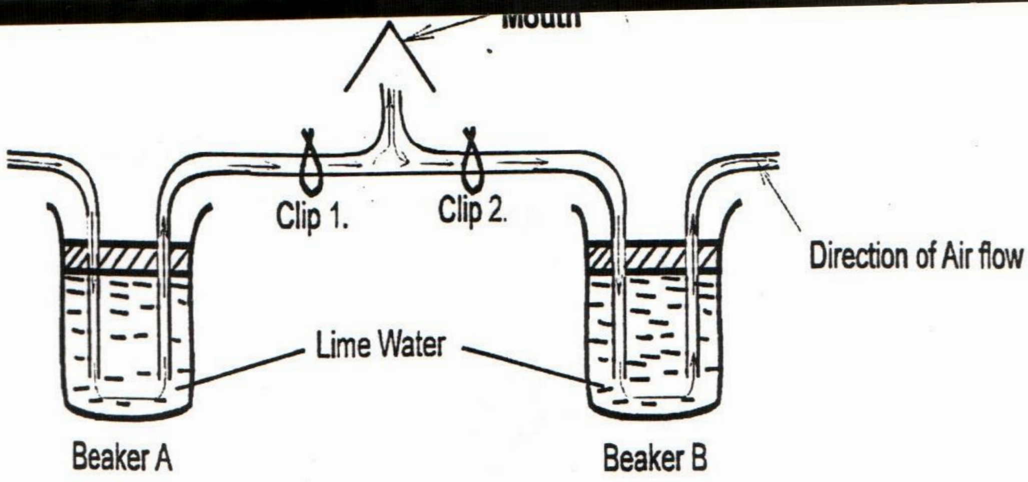
(b) Give your reasons by stating what happens in each container.

5.The diagram below represents the apparatus that can be used to investigate an aspect of gaseous exchange in man.



(i) Identify some errors in the set up that may hinder getting the expected results.

(ii) Explain how you would improve the set up in order to get fair results.

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6. The following statement is not testable scientifically. "Margarine is better for you than Butter".

(a) Explain why it is not testable.

(b) Rephrase the statement in such a way that it is testable.

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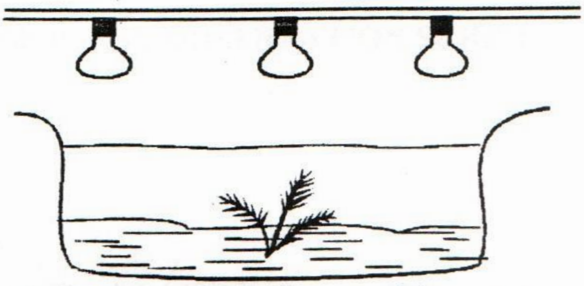
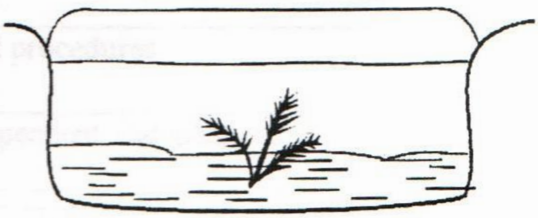
7. Some pupils wanted to run a test to see if light is needed for the pondweed to go on growing. They used four glass tanks full of pond water and planted pondweed in the sand at the bottom of each. When it was growing well in each tank they did this.

- Tank 1 was left in the laboratory in the same conditions as before.

- Tank 2 to was left in the laboratory but with 3 light bulbs shinning on it.



Tank 3 was placed in a dark airy cupboard in the same laboratory.



- Tank 4 was left in the laboratory with the top covered with black plastic sheeting.

They need not have used all four tanks for their test.

(a) Which one of the tank(s) could they have used instead, to find the answer to their question?

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(b) Give reasons for your choice of the tank(s)

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8. A farmer had two types of soils, acidic and alkali soils. He wanted to find out which of the two soils is the best for planting cabbages. Describe how he would go about this.

Appendix three

BIOLOGY OBSERVATION SCHEDULE:

Teacher activity	Number of times per lesson
) Teacher talk	
1a) Teacher asks questions or invites comments which are answered by	
i) Recalling facts and principles	
ii) Applying facts and principles to problem solving	
iii) Reformulating general statements	
iv) Criticizing experimental procedures	
v) Identifying variables (dependent, independent and control)	
vi) Describe planning for an experimental set up	
vii) Describing uses of experimental results	
viii) Describing sources of experimental errors	
ix) Describing sequence of investigations	
x) Generating hypothesis	
xi) Observation	
1b) Teacher makes statements	
i) Of facts and principles	
ii) Of problems	
ii) Of reformulating general statements	
v) Criticizing experimental procedures	
) Identifying variables	
i) Of planning for an experimental set up	
ii) Of uses of experimental results	
iii) Of sources of experimental errors	
) Of sequence of investigations	

x) Of hypothesis or speculation	
xi) Observation	

1c) Teacher directs pupils to sources of information for the purpose of

i) Acquiring facts or principles	
ii) Identifying or problems	
iii) Reformulating general statements	
iv) Criticizing experimental procedures	
v) Identifying variables	
vi) Planning for experimental set up	
vii) Identifying uses of experimental results	
viii) Identifying sources of experimental errors	
ix) Identifying sequence of investigations	
x) Generating hypothesis	
xi) Observations	

Learners activity
and activity initiated and or maintained by pupils

Number of times per lesson

2d. Pupils seek information or consult for the purpose of

i) Acquiring or confirming facts or principles	
ii) Applying facts and principles to problem solving	
iii) Reformulating general statements	
iv) Criticizing experimental procedures	
v) Identifying variables	
vi) Describing planning for an experimental set up	
vii) Describing uses of experimental set up	
viii) Describing sources of experimental errors	
ix) Describing sequences of investigations	
x) Generating hypothesis	

xi) Observation	

2e. Pupils refer to teachers for the purpose of

i) Acquiring or confirming facts or principles	
ii) Applying facts and principles to problem solving	
iii) Seeking guidance when reformulating general statements	
iv) Seeking guidance when criticizing experimental procedures	
v) Seeking guidance when identifying variables	
vi) Seeking guidance when planning for an experimental set up	
vii) Seeking guidance when identifying uses of experimental results	
viii) Seeking guidance when identifying sources of experimental errors	
ix) Seeking guidance when identifying sequences of investigations	
x) Seeking guidance when formulating or testing hypothesis	
xi) Seeking guidance when making observations	

Appendix Four.

RESEARCH AUTHORIZATION

MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY

Telegrams: "EDUCATION"; Nairobi
Telephone: Nairobi 334411
When replying please quote

Ref. No. MOEST 13/001/32C 71/2
and date

JOGOO HOUSE "B"
HARAMBEE AVENUE
P.O. Box 30040
NAIROBI

6th May, 20 02

Catherine Wanja Ndeke
Egerton University
P.O. BOX 536
NJORO

Dear Madam

RE: RESEARCH AUTHORISATION

Following your application for authority to conduct research on 'the effects of Gender, Knowledge and learning opportunities on Scientific creativity among form three Biology students in Nakuru District, I am pleased to inform you that you have been authorised to conduct research in Nakuru Districts for a period ending 30th July, 2002.

You are advised to report to the District Commissioner and the District Education Officer Nakuru District before embarking on the study.

You are further advised to avail two copies upon completion of the research project.

Yours faithfully

A. G. KAARIA
FOR: PERMANENT SECRETARY/EDUCATION

CC
The District Commissioner
Nakuru

The District Education Officer
Nakuru

TO WHOM IT MAY CONCERN:
The Principals,

Please accord her the necessary assistance.

DISTRICT EDUCATION OFFICER
P. O. Box 1028
NAKURU
8/5/02